

# The American Midland Naturalist

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## Flora of the Mount Hamilton Range of California

(A taxonomic study and floristic analysis of the vascular plants)

Helen K. Sharsmith

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### Introduction

A thorough understanding of the complex nature of the California flora awaits detailed investigations of the state's many topographic units which botanically are still largely unexplored. The Mount Hamilton Range was one of these topographic units, and it was chosen as an area for botanical research with the expectation that it would contribute materially to our knowledge of the California flora.

The geographical analysis of any flora is of value only when based upon a reasonably complete knowledge of its component plant species. In the Mount Hamilton Range, botanical exploration began with W. H. Brewer, field botanist of the California Geological Survey from 1860 to 1864, and his journal (Brewer, 1930) gives an account of the areas he penetrated. He and his party climbed Mount Hamilton on September 1, 1861, the earliest recorded ascent. In 1862 he worked along the eastern base of the range from Corral Hollow to Pacheco Pass, penetrating canyons which open into the San Joaquin Valley (Fig. 1). Some of these localities have not been visited since by botanists. The types of *Streptanthus Breweri*, *Monardella Breweri*, *Clarkia Breweri*, and *Oenothera deltoidea* var. *cognata* were collected on this trip.

Brewer's collections are at the Gray Herbarium, but many duplicates are in California herbaria. E. L. Greene (1893a) spent a week on the summit of Mount Hamilton in 1893. His collections are in the herbarium of the University of Notre Dame. In 1903 A. D. E. Elmer collected rather extensively on the western side of the range, and also visited Arroyo Mocho, San Antonio



Fig. 1. Mount Hamilton Range. All collecting localities are included in this map. .... = boundaries of the range. ----- = roads. ——— = county boundaries.

Valley, Cedar Mountain, Red Mountain, Arroyo del Puerto, and Adobe Valley; his collection is at Stanford University, and duplicates are in various western herbaria. In 1907 A. A. Heller (1907) visited the Alum Rock area and Mount Hamilton. Many of his specimens are at Stanford University, the University of California, and other western herbaria. Several other early California botanists made short collecting trips to the western side of the range, among them: T. S. Brandegee (Mount Hamilton in 1890), W. R. Dudley (Pine Ridge and Gilroy Hot Springs in 1895), J. Burt Davy (Mount Hamilton in 1897), R. J. Smith (Mount Day, Oak Ridge, Los Buellis Hills, and Mount Hamilton in 1904, 1906, and 1908), H. P. Chandler (Mount Hamilton in 1906), and R. L. Pendleton (Alum Rock and Mount Hamilton in 1907). Their collections are variously represented at the herbaria of the University of California, Stanford University, and California Academy of Sciences.

Among recent collectors, R. F. Hoover made several explorations along the eastern margin of the range from 1935 to 1938; his collections are in the University of California herbarium or his personal herbarium. The field staff of the Vegetative Type Map Herbarium of the United States Forest Service penetrated several unexplored areas between 1935 and 1938, particularly on the western side, and their collections and Hoover's gave valuable assistance in the present study. Field work was carried on by the writer from 1934 to 1937. Explorations were limited mainly to an east-west transect which included Mount Hamilton, the highest mountain in the range (Figs. 1 and 2), although many areas north and south of the transect were penetrated. This plan was chosen because 1) it embodied the major vegetational and floristic features, and 2) better knowledge of the flora was obtained by thoroughly investigating the transect area than would have been possible by a more superficial exploration of the entire range. A complete set of collected specimens was deposited at the University of California herbarium, and the duplicates were distributed from there.

There are 761 species and varieties of Mount Hamilton Range vascular plants listed in this paper. The following tabular summary indicates their taxonomic position:

|                       | Families | Genera | Species |
|-----------------------|----------|--------|---------|
| Pteridophyta .....    | 5        | 13     | 16      |
| Gymnospermae .....    | 3        | 4      | 6       |
| Monocotyledonae ..... | 10       | 44     | 110     |
| Dicotyledonae .....   | 68       | 270    | 629     |
| Totals .....          | 86       | 331    | 761     |

The three largest families are the Compositae (61 genera, 126 species), Gramineae (22 genera, 53 species), and Leguminosae (12 genera, 53 species). Other well represented families are: Scrophulariaceae, Liliaceae, Cruciferae, Hydrophyllaceae, Ranunculaceae, Umbelliferae, Polygonaceae, and Polemoniaceae.

These 761 species of vascular plants represent 19 per cent of the 4019 species listed by Jepson (1925) for the entire state of California. There are





whole (about 40 per cent according to Jepson). The distinction and diversity of the Mount Hamilton Range flora seem to be due to the same factors which have resulted in the distinction and diversity of the California flora as a whole, namely the development or migration and establishment of diverse floristic elements in response to the combined influences of a complex geologic history and a resultant complexity of topography, climate, and soils.

### Analysis of the Factors Relating to the Distribution and Origin of the Flora

#### PHYSIOGRAPHY

The Mount Hamilton Range is one of the several subdivisions of the Diablo Range of the inner South Coast Ranges of California. The Diablo Range (Figs. 2 and 3) extends in a northwest-southeast direction as a more or less continuous mountain chain some twenty to thirty miles wide, from San Pablo Bay in central California to Polonio Pass in northeastern San Luis Obispo County. South of Polonio Pass in the inner South Coast Ranges, the Temblor Range connects the Diablo Range with the Tehachapi Mountains of southern California, and the Tehachapi Mountains in turn link the inner South Coast Ranges with the Sierra Nevada (Anderson and Pack, 1915; Anderson, 1905; Clark, 1929). On the west the Diablo Range is bordered, from north to south, by San Francisco Bay, Santa Clara Valley, San Benito Valley, the south end of the Gavilan Range where it merges with the Diablo Range, the Salinas Valley, and Cholame Valley. On the east it is bordered for its entire length by the San Joaquin Valley. The interior of the Diablo Range has a minimum altitude of 2000 to 3000 feet throughout its length, and is broken by only four or five east-west passes. These represent major topographic breaks, dividing the Diablo Range into several more or less distinct topographic subdivisions which roughly correspond to the structural subdivisions of the range. The topographic subdivisions overlap somewhat, but in general they form northwest-southeast trending units known as Contra Costa Hills (the most northerly), Mount Diablo, Mount Hamilton Range, Panoche Hills, San Carlos Range (which is here regarded as including the Panoche Hills), and the Estrella Hills (Whitney, 1865).

The Mount Hamilton Range (Fig. 1) subdivision of the Diablo Range forms an unbroken, well defined, and relatively isolated mountain block approximately fifty miles long and thirty miles wide. It is delimited on the north by Niles (Alameda Creek) Canyon, Sunol Valley, Livermore Valley, and Altamont (Livermore) Pass (740 feet), on the south by Pacheco Pass (1470 feet), on the west by the Santa Clara Valley, and on the east by the San Joaquin Valley. The Altamont and Pacheco passes represent major topographic breaks in the Diablo Range as a whole. Lawson and Palach (1902) consider the Contra Costa Hills (named the Berkeley Hills in their paper) as overlapping the Mount Diablo subdivision and merging with the Mount Hamilton Range in the vicinity of Niles Canyon. The Mount Hamilton Range is least sharply delimited here, but the break formed by Niles Canyon



Fig. 3. Map of California; showing relationship of Diablo Range to other mountainous areas of California.

and Sunol Valley connects with the Santa Clara Valley on the west and Livermore Valley on the east and forms a fairly well defined topographic, if not structural, boundary for this portion of the Mount Hamilton Range.

On the western side of the Mount Hamilton Range, the main western crest (Figs. 1 and 4) rises to an altitude of 3000 to 4000 feet, and consists, from north to south, of the following peaks and ridges: Oak Ridge (3280 feet), Mount Day Ridge (Mount Day, 3935 feet; Black Mountain, 3850 feet), Mount Hamilton (4209 feet), and Copernicus Peak<sup>1</sup> (4372 feet, the highest point in the Mount Hamilton Range and the third highest point in the Diablo Range as a whole), Mount Santa Isabella (4223 feet), Pyramid Rock (4014 feet), and Pine Ridge (3626 feet). South of Pine Ridge the western crest is not sharply defined. For the greater part of the length of the range the main western crest is paralleled by a subsidiary marginal ridge which

<sup>1</sup> It forms the highest of the several peaks constituting the Mount Hamilton summit, and is usually considered as synonymous with Mount Hamilton.

rises sharply to an average height of 1000 feet above the Santa Clara Valley floor and is broken only by the trough formed by the entrance of Coyote Creek into the Santa Clara Valley. This marginal ridge is separated from the main western crest by Calaveras Valley in the north, Hall's Valley, San Felipe Valley, and Coyote Valley successively southward.

On the eastern side of the range, an eastern crest (the Red Mountains) parallels the western crest and reaches an altitude of over 3600 feet. This eastern crest extends almost the entire length of the range, but the highly distinctive topography of the Red Mountains is best developed in the summit area which marks the boundary line between Santa Clara and Stanislaus counties. Here the Red Mountains consist of a broken, rugged, mountain mass, with steep canyon walls of unstable talus which frequently lie at an angle of  $35^{\circ}$  or more (Fig. 5). To the east the Red Mountains decrease gradually in altitude to form a marginal foothill belt of rolling hills from five to fifteen miles wide, which disappears beneath the alluvial deposits of the San Joaquin Valley. In this foothill area differential erosion controls the drainage pattern, which consists of streams draining eastward into the San Joaquin Valley from the summit of the Red Mountains; this contrasts with the mainly north-south antecedent drainage pattern of the interior and western side of the range. The major eastern canyons thus formed are, from north to south, Corral Hollow, Lone Tree Canyon, Hospital Canyon, Arroyo del Puerto, Salado Canyon, and Orestimba Canyon.

The interior of the Mount Hamilton Range, between western and eastern crests, consists of a mountainous area approximately five to ten or more miles wide, the topography of which is rough, but with no striking diversity of relief (Fig. 6). It represents a uniformly uplifted surface in which the original



Fig. 4. The northeast chaparral and forest covered slopes of Mount Hamilton from Packard Ridge; showing characteristic topography of the main western crest of the range.



Fig. 5. Red Mountains from the western slopes of Adobe Creek Canyon; showing the rugged, sparsely chaparral covered topography of this region. The steep talus deposits of Adobe Creek Canyon can be seen in the foreground.



Fig. 6. Sugarloaf Butte, and tributary to Arroyo Bayo; a typical view in the interior of the range.



erosional pattern has undergone little modification, the streams still flowing at grade in the old, undisturbed valleys (Willis, 1925). The ridges mainly parallel the longitudinal axis of the range, and reach a height of 2500 to 4000 feet, but their summit areas do not, in general, stand out as isolated peaks. Their slopes are only moderately steep, the streams, all of which drain into the Santa Clara Valley, occupy relatively wide channels which seldom lie below 2000 feet altitude, and in general the relief indicates a stage of early topographic maturity. Two fairly extensive valley areas occur in this interior portion of the range, the San Antonio Valley and the Santa Isabella Valley.

To summarize, the Mount Hamilton Range represents a distinct physiographic unit of the Diablo Range, its major features of relief best developed in a northwest-southeast direction paralleling the longitudinal axis of the range. The range can be rather easily divided into a western portion which arises abruptly from the Santa Clara Valley plains and consists of the flanking subsidiary ridge and the steep main western crest, an interior area, and an eastern portion which consists of the eastern crest (Red Mountains) and a foothill zone which drops gradually to the San Joaquin Valley plains. These major topographic features express the combined control of forces which elevated the range and the varying resistance to erosional forces of the rocks which compose it (Willis, 1925). The same factors have exerted a control upon plant distribution within the range, so that the major floristic changes coincide with the major topographic changes, and the floristic zones parallel the longitudinal axis of the range, dividing the flora into more or less distinctive western, interior, and eastern components as will be described.

#### GEOLOGIC HISTORY

Most of the surface area of the Mount Hamilton Range consists of rocks of the Franciscan series (Fig. 2). Because of the probable relationship of these rocks to the phytogeography of the Mount Hamilton Range, their rôle in the geologic history of the range will be described in some detail. The Franciscan rocks represent the oldest and most extensively exposed series of sedimentary rocks in the central and South Coast Ranges (Taliaferro, 1943). Their southern limit in the inner South Coast Ranges coincides approximately with the southern limit of the Diablo Range (Reed, 1933, fig. 16, p. 73). In the units of the Diablo Range south of the Mount Hamilton Range, they form a progressively narrower belt which is discontinuous at its southern extremity (Jenkins, 1938). In the Mount Hamilton Range they total 15,000 to 20,000 feet in thickness (Templeton, 1913), and compose the entire surface area of the range except on north, west, and east margins. At the northern margin of the range they dip beneath Cretaceous and Tertiary sediments. Northward in the Diablo Range they occur in small areas in the Contra Costa Hills and on the summit of Mount Diablo (Turner, 1891; Taft, 1935). In the inner North Coast Ranges they reappear in Lake County and adjoining areas of Napa, Sonoma, Colusa, and Glenn counties (vicinity of Clear Lake, Fig. 2), and northward they form a considerable portion of the surface layer of the North Coast Ranges. In the outer South Coast Ranges they occur in the

Santa Cruz Mountains and San Francisco peninsula; in the outer North Coast Ranges they are found from the Marin peninsula (Mt. Tamalpais region, Fig. 2) northward.

The Franciscan rocks had their origin as marine sediments laid down probably in the early Jurassic. During the Upper Jurassic they were highly folded and faulted and intruded with large quantities of igneous rocks. Consequently the Franciscan series is extremely complex and intensively altered, being composed of various minerals and many kinds of sedimentary, metamorphic, and igneous rocks mingled together. Sandstones, shales, cherts, and conglomerates are abundant among the sedimentary rocks (Davis, 1918a, b; Turner, 1891; Fairbanks, 1894). Large masses of jasper and variously related slates and schists characterize the metamorphic areas. The igneous rocks are mainly intrusive and ultrabasic or basic, common types being basalt, diabase, pyroxenite, gabbro, and peridotite (the latter now almost entirely altered to serpentine and associated ferromagnesian rocks). Throughout the Franciscan rocks of the Coast Ranges, serpentine, either of sedimentary or igneous origin, is frequent (Anderson and Pack, 1915; Anderson, 1905; Fairbanks, 1898; Turner, 1891), and from the San Carlos Range to Clear Lake in Lake County it is very abundant. North of Lake County the serpentine decreases in abundance along with a gradual change in other constituents of the Franciscan rocks.

Varying and sometimes contradictory accounts of the diastrophic history of the South Coast Ranges have been advanced (Willis, 1925; Clark, 1925, 1927, 1929, 1930, 1935; Reed, 1933). Their structure is highly complex. One of the most logical explanations is that the present structural units, including the Diablo Range of which the Mount Hamilton Range is a part, were brought into being by continued gentle compression along the continental margins upon a region of already diversified topography and structure (Taliaferro, 1943). Submerged troughs and elevated land masses had their start in the upper Cretaceous and Eocene, attained a continuous development in the Miocene, and reached their maximum in the strong diastrophisms of late Pliocene and early Pleistocene. By that time the present major structural and topographic features were developed, the Coast Ranges forming an archipelago system (Anderson, 1908; Lawson, 1893) in which the mountain ranges were insular land masses. The present exposure of the Franciscan rock series roughly coincides, at least in the Diablo Range, with these insular land masses. Thus the Mount Hamilton Range, as one of the structural units of the Diablo Range of the South Coast Ranges, can be considered an insular land mass which has been at least partly above water since the middle Miocene, at which time present-day climatic zones and a modern flora and fauna were beginning. The Mount Hamilton Range was partly or entirely surrounded by marine embayments until after the Pliocene-Pleistocene revolution, but its present exposure of Franciscan rocks is roughly correlated with that portion of the range which was above water during at least the later periods of coastal subsidence.

The western marginal ridge of the Mount Hamilton Range consists of

Cretaceous and Tertiary, mainly unaltered, marine sedimentary strata (shales, sandstones, conglomerates, etc.). It is in fault contact with the Franciscan rocks of the main part of the range (Sunol graben: Templeton, 1913; Vickery, 1925). The eastern marginal foothill strip consists of similar sediments (Anderson and Pack, 1915), and they also lie in fault relationship with the Franciscan rocks of the interior (Clark, 1927). In this area, however, the fault zone is not always direct or clear, and the strata are soft, so that differential erosion controls the topography to a far greater extent than on the western side of the range. The northern margin of the range likewise is composed of Cretaceous and Tertiary (and also Quaternary) sediments lying in fault relationship to the Franciscan rocks of the interior of the Mount Hamilton Range. To the south the Franciscan rocks continue across the Pacheco Pass into the San Carlos Range (Fig. 2).

Summarizing the geology of the Mount Hamilton Range, it is seen to be a land mass which has been above water probably since the early part of the Tertiary. It is composed mainly of altered Franciscan sediments and intruded basic igneous rocks, the Franciscan basement being overlain by and in fault contact with later, mainly unaltered marine sediments along the north, east, and west margins of the range. Although the Mount Hamilton Range has developed as a more or less structurally distinct land mass, its geologic history is similar to that of the other land masses of the Diablo Range, and more generally to all the South Coast Ranges. More of the total surface area of the Mount Hamilton Range belongs to the Franciscan series, however, than to any of the other units of the South Coast Ranges, and no larger expanse of Franciscan rocks occurs until the central portion of the North Coast Ranges is reached. These Franciscan rocks, due to their long history as exposed land masses, and to the distinctive soils they form, are believed to control, in part, the present distribution of plant species in the Mount Hamilton Range and in the central Coast Ranges as a whole, as discussed subsequently.

#### CLIMATE

Russell's classification (1926) of the climates of California is based on that of Köppen and gives a basis for determining the climatic provinces of the Mount Hamilton Range, and for analyzing, in generalized manner, the climate of the Mount Hamilton Range in relation to the Coast Ranges as a whole. According to Russell, the western and interior portions of the Mount Hamilton Range are characterized by a humid, mesothermal, cool-winter "Mediterranean" climate which is divisible into two types, a cool-summer "heather" type, in which the warmest month of the year averages below 71° F., and a hot-summer "olive" type, in which the warmest month averages above 71° F. From the summit of the main western crest of the range to its western base, the cool-summer type occurs, while in the interior of the range, the hot-summer type occurs. A Mediterranean climate of these two types is found throughout the greater part of the Coast Ranges. In the North Coast Ranges, the cool-summer "heather" type is predominant, and only two small areas of the hot-summer "olive" type occur (one in the vicinity of Clear Lake, Lake

County, the other in Mendocino County). It is significant to plant distribution that the small area of hot-summer climate in southern Lake County coincides with the area of Franciscan rocks found there (p. 9). The cool-summer "heather" type also is predominant in the northern part of the South Coast Ranges, but south of the Santa Cruz Mountains and the Mount Hamilton Range, it is restricted mainly to a coastal strip, while in the interior (Gavilan Range and Santa Lucia Mountains) the hot-summer "olive" type occurs.

The eastern side of the Mount Hamilton Range, from the summit of the eastern crest (Red Mountain) to the San Joaquin Valley, is characterized by an arid, hot, steppe climate. In the units of the Diablo Range south of the Mount Hamilton Range, this steppe climate predominates. It forms a marginal band in the foothills around the entire San Joaquin Valley, and gives way at the borders of the San Joaquin Valley to the arid, hot, desert (Mohave-type) climate of the latter. The steppe climate represents a climatic transition between the arid climate of the San Joaquin Valley and the humid climate of the major portion of the Coast Ranges.

Reviewing the above, it is seen that, in a general matter the Mount Hamilton Range can be divided into three longitudinal climatic zones, a western zone of cool-summer Mediterranean climate, an interior zone of hot-summer Mediterranean climate, and an eastern zone of arid steppe climate which is bordered by the arid desert climate of the San Joaquin Valley. These three climatic zones correspond, in general, to the three major topographic areas of the range, and in part the former are controlled by the latter (McAdie, 1903, 1914). Together these topographic areas and climatic zones are largely responsible for the longitudinal zonation of the flora within the Mount Hamilton Range.

The presence of three climatic zones in the Mount Hamilton Range implies a considerable climatic diversity. This becomes apparent when the major factors determining the climatic zonation are analyzed. Considering first rainfall, the higher prevailing westerly winds pass over the Mount Hamilton Range (and other parts of the Coast Ranges) entirely, dropping their moisture on the western slope of the Sierra Nevada, while the lower winds precipitate much of their moisture on the western side of the Santa Cruz Mountains before the Mount Hamilton Range is reached. Nonetheless, the steep western slopes of the Mount Hamilton Range act as a second effective bulwark in intercepting the lower prevailing westerly winds and in depriving them of much of their remaining moisture. Consequently the interior of the range receives considerably less rainfall than the western slopes. The eastern crest of the range catches some of the moisture left in the lower winds, draining it into the interior of the range, so that the eastern foothill area receives even less precipitation than the interior area. Relative humidity, temperature, and atmospheric pressure are affected as well, although to a lesser extent than rainfall, and as a result the climate of the eastern side of the range is markedly continental in comparison to the maritime climate on the western side of the range.

On the western crest, the summit of Mount Hamilton (including Copernicus Peak, highest point in the range) has a maximum rainfall for the range. Rain occurs every month of the year on Mount Hamilton, but the summer rains are light and infrequent. Over half the annual rainfall occurs between December and March. During the winter months the precipitation is frequently in the form of snow. The average seasonal precipitation for Mount Hamilton is 32.28 inches.

No rainfall data are available for the interior area of the Mount Hamilton Range. Some idea of the average seasonal precipitation can be obtained, however, by considering the data from other areas in the South Coast Ranges which lie in the same hot-summer climatic zone. It is probably safe to assume that the rainfall in the interior of the Mount Hamilton Range is about 15 inches, or less than half that of the western crest. July and August are almost rainless in the interior. The streams are mainly intermittent, and carry running surface water only in the winter, spring, and early summer months.

The average annual precipitation for the eastern side of the Diablo Range (which would include the eastern side of the Mount Hamilton Range as well) is only 9 inches according to Anderson and Pack (1915). The eastern side of the Diablo Range receives little or no more average rainfall than the upper end of the San Joaquin Valley at the base of the Tehachapi Mountains.

Summer fogs are frequent on the western slopes of the Mount Hamilton Range, and are important in the development of the strongly maritime climate which characterizes this side of the range (Byers, 1930). The Golden Gate and San Francisco Bay (Fig. 2) furnish the main path of entrance for the fogs, from whence they are carried southward down the San Francisco Bay to spread out in the Santa Clara Valley and on its flanking slopes. Frequently, however, the outer Coast Ranges from San Mateo County to Mount Tamalpais are low enough to allow the fogs to drift in over their summits. Chittenden Pass, between Monterey Bay and the southern end of the Santa Clara Valley, also acts as a path of entrance for fogs. The fogs are often high enough to reach the summit areas of the western crest of the Mount Hamilton Range. Occasionally they may spread via Niles Canyon into Livermore Valley at the northern end of the Mount Hamilton Range.

Temperature varies considerably between western, interior, and eastern portions of the range. It is, of course, hottest, and the diurnal and seasonal extremes are greatest on the eastern side, but no accurate data are available. The mean annual temperature of Mount Hamilton is 52.7° F., the mean temperature of the coldest month (January) is 39.7° F., and the mean temperature of the warmest month (July) is 69.4° F. Temperature appears to be of less importance than rainfall as a climatic factor in the Mount Hamilton Range. Russell (1926) corroborates this by stating that the steppe climate of the San Joaquin Valley and inner portion of the South Coast Ranges (including the eastern side of the Mount Hamilton Range) falls into this subdivision not on the basis of temperature, but primarily because of "rain shadow" conditions caused by areas of higher altitude toward the west.



## SOILS

The surface area of the Mount Hamilton Range, as already stated, is almost entirely composed of rocks of the Franciscan series. These rocks were highly fractured as a result of the diastrophic forces exerted upon them during the formation of the Mount Hamilton Range. As a consequence, the Franciscan rocks, although predominantly metamorphic and igneous in composition, are easily fragmented by weathering. On the ridges of the Mount Hamilton Range, Franciscan bed rock is frequently exposed, but often all bed rock is covered with more or less disintegrated mantle rock. The slopes of the ridges tend to form unstable rock slides, the size of the constituent rock fragments depending largely upon the degree of fracturing of the bed rock. Such talus deposits are a characteristic feature of the topography throughout the interior of the range, but they reach their highest development in the Red Mountains (Figs. 7 and 8). Here the serpentine which composes the area is very friable. The arid climate with rain concentrated during short periods, winds, gravity,



Fig. 7. A precipitous, unstable, almost barren talus deposit in Adobe Creek Canyon of the Red Mountains.



Fig. 8. Adobe Creek Canyon of the Red Mountains; showing again its precipitous slopes and unstable talus deposits.

and sparseness of the vegetational cover, all combine to weather and erode the serpentine into steep, unstable, porous rock slides of relatively small fragments (mainly rubble or gravel) which often extend 2000 feet or more from ridge top to canyon floor. On talus deposits of this type, a true soil scarcely can be said to exist. It is a skeletal soil, predominantly mineral in composition, and chiefly conditioned by the character of the underlying rock rather than by climate or vegetational cover. In these areas plant growth is usually highly limited, both in numbers of species and individuals. A few species show adaptations to the unstable substratum. *Psoralea californica*, for example, has only a low tuft of leaves and stems above ground, but its stout, deeply seated root may extend twelve inches or more underground.

Under the influence of an even more arid and hot climate, the soft, unaltered sediments which occur east of the Red Mountains have weathered in essentially the same manner as the Franciscan rocks of the interior and eastern crest of the range, producing porous soils which are deficient in organic matter. In general, however, the soils from these sedimentary rocks are much richer in lime than the soils formed from the Franciscan rocks, and their vegetational cover is not so sparse.

Throughout the interior and eastern side of the range, well developed soils are found only on the more gentle slopes (mostly grassland or savannah areas), in those portions of the canyon floors not occupied by the wide gravelly flood channels of the streams, and in the occasional valley areas. On the

western slope of the range and the upper reaches of the western crest, in both sedimentary and Franciscan rocks, well developed soils are much more prevalent, and a soil climax is more generally approached. In this area, soil formation is chiefly conditioned by the complementary effects of a more maritime climate and a more extensive vegetational cover rather than by the nature of the underlying rock. In the forested areas of the sheltered ravines and upper slopes of the western crest, the soil is rich in humus.

As indicated above, climate, vegetational cover, and the physical nature of the rocks involved, have played interacting parts in the production of soil in the Mount Hamilton Range. Conversely, the degree to which development of the soil has proceeded in various portions of the range determines in part the relative abundance and nature of the vegetational cover of the range.

Another related factor which exerts a very considerable influence upon plant distribution within the range is the chemical nature of certain of the soils. It has been pointed out that ultrabasic or basic, intrusive, igneous rocks form a large and important element in the Franciscan series. Particularly abundant among these igneous intrusives is the group of ferromagnesian minerals of which peridotite was originally the most important constituent. The rocks of this group are classed as basic to ultrabasic (i.e., having a low silica content, little or no free quartz, and usually with large amounts of iron), and the peridotite, being very subject to alteration, has been transformed almost entirely into serpentine. The physical and chemical processes of weathering ultimately break down the serpentine into brown, ferromagnesian soils which represent a mixture of carbonates and silicates (Pirsson, 1926). The soils so formed lack potassium and calcium, and are high in magnesium content.

Such serpentine soils are often exceedingly infertile. According to Gordon and Lipman (1926), the infertility of these soils is due, not to a specific toxicity induced by their high magnesium content, but to four causes: 1) they have a very low concentration of available ions which are important to plant growth, 2) they have a low nitrate content, 3) they have a high pH value (averaging 8.1 on the samples tested), and 4) they are poor in potassium and phosphates. Of these, Gordon and Lipman believe the high pH to be the most significant factor in rendering serpentine soils infertile.

In the Mount Hamilton Range, the Red Mountains form the major serpentine area. They are composed of iron-impregnated serpentine rocks with occasional outcroppings of magnesite, manganese, and silicious rocks (Calif. St. Min. Bur. reports, 1893, 1915). The iron imparts a red color to the rocks, from which the mountains derive their name. The infertility of the soils in the Red Mountains is strikingly exemplified by their very sparse vegetational cover. There are also occasional bands of serpentine along the western crest of the Mount Hamilton Range. On the Mount Day Ridge, the serpentine rocks are compact, waxy, and greenish, very different in appearance from the more heavily iron impregnated serpentine of the Red Mountains.

Throughout the South Coast Ranges serpentine is a frequent constituent of the Franciscan rocks. The Mount Diablo summit includes a narrow band of

serpentine and associated igneous rocks. Serpentine is also common in the southern portion of the Franciscan series of the North Coast Ranges.

Although serpentine frequently inhibits plant growth, its peculiar qualities may cause it to favor the growth of certain species which require an excess of magnesium ions in relation to calcium ions. Serpentinous species usually have a highly developed root system and poorly developed surface parts (Braun Blanquet, 1932). A limited number of plant species appear to be obligate to areas of serpentine rocks, and in these cases plant distribution is primarily a matter of local, edaphic control. This is borne out in the distribution of certain species in the Mount Hamilton Range, such as *Allium Parryi*, *A. fimbriatum*, *Fritillaria folcata*, *Salix Breweri*, *Quercus durata*, *Streptanthus Breweri*, *Linum Clevelandii*, *Clarkia Breweri*, *Garrya Congdoni*, *Emmenanthe penduliflora* var. *rosea*, *Collomia diversifolia*, and *Cirsium campylon*.

As pointed out by Gordon and Lipman (1926), the characteristics of a serpentine-derived soil also occur in other magnesium-high soils. As a whole, magnesium rocks are not good soil formers. Although serpentine is the most abundant magnesian rock of the Franciscan series, other magnesian minerals and rocks are frequent (magnesite; olivine, a mineral constituent of basalt and peridotite; pyroxene, a common mineral in pyroxenite and metamorphic schists; etc.), and the soils they form exert a control upon plant distribution similar to that of serpentine.

Other igneous rocks of the Franciscan series, and likewise some of the metamorphics, are poor soil formers. Schists and gabbro, unless associated with accessory minerals, give infertile soils. Jasper, a common mineral among Franciscan rocks in the South Coast Ranges, is mainly silicon dioxide, and gives an inert soil.

The chemical nature of the soils appears to influence plant distribution in the Mount Hamilton Range throughout the surface area of the Franciscan rocks, although its effect is most strongly exhibited in the serpentine areas. Other environmental factors being equal, plant distribution is affected similarly in other portions of the Coast Ranges where these rocks appear in abundance. This accounts, in part, for the limited and discontinuous distribution of certain inner Coast Range species to be discussed. It is noteworthy that north of Lake County the Franciscan rocks undergo a gradual change, the serpentine and jasper constituents becoming less abundant, and hornblende, feldspar, and mica-like schists and slates becoming more frequent. The latter group forms good soils, and this is probably of significance in the northward restriction of certain of the central Coast Range endemic species.

In conclusion it is important to note that the influence which the chemical nature of the soils, particularly serpentine, has upon plant growth, species evolution, and species distribution, forms the basis of one of the most salient and interesting of the many baffling distributional problems involved in the California flora. Any satisfactory solution of this problem must await the combined efforts of plant physiologist and systematic botanist.

## INFLUENCE OF MAN

In the Mount Hamilton Range the biotic influence expresses itself today not so much as a factor in the establishment and maintenance of the native plant species as in their restriction and extermination. The erection of the Lick Observatory upon the summit of Mount Hamilton in 1876 has resulted in year-round human occupancy of this area. The establishment of a permanent colony here, and the subsequent influx of tourists and visitors has led to a marked local alteration of natural conditions.

Observatory residents report that some of the native species which were frequent on the summit area of Mount Hamilton twenty or more years ago are now uncommon or very rare. Among these species are *Clarkia Breweri*, *Arabis Breweri*, and *Calochortus venustus*. Their gradual restriction in this region no doubt is due not only to the disturbed conditions brought about by human occupancy and the resulting competition with introduced weeds, but also to the rapid increase of deer following the establishment of a state game preserve on the upper slopes of the mountain in recent years.

The lower western slopes of the range have been intensively cultivated for many years. Here the original flora has almost disappeared, both as a result of cultivation and of the competition offered by the invasion of alien species, for it is in this area that most of the aliens are definitely established. As an example, *Avena fatua* is abundant here, while in other portions of the range it is merely adventive.

The Calaveras Reservoir has flooded the Calaveras Valley and the lower portion of the Arroyo Hondo, exterminating the flora of this region (and exterminating *Acanthomintha lanceolata* Curran at its type locality).

Except in the areas already mentioned, the native vegetation of the Mount Hamilton Range as a whole has been relatively little disturbed by the influences of man, domesticated animals, and the concomitant changes in the native fauna. The interior of the range and particularly the eastern side are very sparsely settled, although these areas have been long subject to cattle grazing. Most of these areas are still open range, and only isolated patches of ground are under cultivation. On the eastern side of the range, sheep have been grazed since a time prior to Brewer's botanical explorations in 1862. Part of the paucity of the vegetational cover here may be a result of overgrazing. The only significant modification in the native flora of the interior and eastern side of the range, however, is the establishment in the grassland areas of a number of alien grasses, such as *Bromus rubens*, *B. mollis*, *Hordeum murinum*, *Lolium multiflorum*, *Koeleria cristata*, and *Avena barbata*, and the extensive establishment of *Erodium cicutarium*.



## Analysis of the Vegetation

## PLANT COMMUNITIES

The California Forest and Range Experiment Station of the Division of Forestry, United States Department of Agriculture, has completed the following vegetation type maps (not yet published) of the Mount Hamilton Range: Carbona, Pleasanton, Tesla, Mount Hamilton, Morgan Hills, and Orestimba quadrangles. Maps are in progress for the other portions of the range. Due to this work and because the emphasis of this paper is floristic rather than vegetational, only a brief description of the more important plant communities and their occurrence will be given.

In the vicinity of Mount Hamilton, the western slopes of the range are mainly grassland. Farther south, the chaparral of the interior extends over the summit of the western crest and covers the western slopes scantily or thickly. The grassland on the western side of the range often supports a scattered growth of oaks, while patches of a sagebrush community (mainly *Artemisia californica*) are frequent on the dryer slopes. In the more mesophytic areas (canyons and north-facing slopes), the grassland gives way to brush and woodland (deciduous thicket scrub and broad sclerophyll forest of Cooper, 1922). Species typical of the brush are *Ribes malvaceum*, *Rosa californica*, *Holodiscus discolor*, *Amelanchier alnifolia*, *Osmaronia cerasiformis*, *Toxicodendron diversiloba*, *Symphoricarpos albus*, *Sambucus coerulea*, etc. Species typical of the woodland are *Quercus agrifolia*, *Q. chrysolepis*, *Q. Kelloggii*, *Q. Wislizenii*, *Umbellularia californica*, *Acer macrophyllum*, and *Rhamnus californica* subsp. *tomentella*. The higher summit areas of the western crest support a mixed coniferous-broad sclerophyll forest. The typical broad sclerophyll elements in this forest are the same as the woodland species listed above, while *Pinus Coulteri* is the only important conifer. On the northerly slopes of the western crest or in the canyons on the western slope, however, local conditions support occasional pockets of *Pinus ponderosa*, a species usually found at somewhat higher altitudes. There is also the infrequent occurrence, in similar pockets, of typical outer Coast Range species such as *Torreya californica* and *Arbutus Menziesii*.

In the interior of the Mount Hamilton Range, the climax chaparral association (sensu Cooper, 1922<sup>2</sup>) is the dominant community. The most important species in this highly xerophytic community, in the Mount Hamilton Range as elsewhere in California, is the chamise, *Adenostoma fasciculatum*. It occupies large areas in the interior of the range as a pure or almost pure dominant. *Ceanothus cuneatus* is the second most important constituent of the climax chaparral association, and other representative species are *Quercus dumosa*, *Cercocarpus betuloides*, *Photinia arbutifolia*, *Prunus ilicifolia*, *Ceanothus leucodermis*, *Rhamnus crocea* subsp. *ilicifolia*, *Garrya Fremontii*, *Arctostaphylos glauca*, *A. glandulosa* var. *Campbellae*, *Eriodictyon californicum*, etc.

<sup>2</sup> Cooper includes two associations under chaparral (broad sclerophyll scrub) formation—climax chaparral association and coniferous forest chaparral association.

Extensive areas of grassland or savannah (grassland supporting a thin growth of *Pinus Sabiniana*, *Juniperus californicus*, or various oak species, mainly *Quercus Douglasii* and *Q. lobata*) also occur in the interior of the range, particularly in the valleys or on their adjacent slopes (Fig. 6). North-facing slopes of ridges support occasional patches of brush or woodland, although these are composed of less mesophytic species than similar areas on the western slopes of the range. Typical species are *Berberis dictyota*, *Ribes quercetorum*, *Ribes malvaceum*, *Prunus emarginata*, *Forestiera neomexicana*, and *Lonicera subspicata* var. *Johnstoni*.

According to Cooper (1922), chaparral formerly controlled much of the area now occupied by grassland in the Coast Ranges. As an illustration he describes (p. 78) the "patchy remnants of chaparral mainly *Adenostoma*" found on the grassy hills of the western slopes of the Mount Hamilton Range above Coyote Creek, while toward the interior of the range the "numerous ridges are covered with an irregular mosaic of chaparral and grassland," deeper penetration finally bringing one to a central region of solid chaparral. Wherever mature individuals of *Adenostoma fasciculatum* are found in grassland, either isolated or in patches, Cooper believes that chaparral was formerly dominant. Following Cooper, this would indicate that most of the present areas of grassland and savannah on the western side and interior of the range may at one time have been occupied by climax chaparral, fire having been the main factor involved in its destruction.

On the eastern crest of the Red Mountains area, a thin cover of chaparral occurs on the more stable talus deposits. Here again the chaparral is predominantly or exclusively *Adenostoma fasciculatum*, but serpentinophilous species are frequently intermingled, the most characteristic being *Quercus durata* and *Garrya Congdoni*. As already mentioned, the more unstable talus deposits, which give the Red Mountains their distinctive topography, are very barren. They are almost or entirely devoid of shrubs, and the herbaceous cover is widely spaced. The latter consists of annual or perennial species which are adjusted to an unstable, highly xeric, and ecologically distinctive substratum, of which the following are typical: *Allium Parryi*, *A. fimbriatum*, *Streptanthus Breweri*, *Psoralea californica*, *Linum Clevelandii*, *Clarkia Breweri*, and *Campanula exigua*. Grassland is poorly represented in this region.

In the eastern foothill area, chaparral and savannah or grassland are frequent, the latter becoming predominant as the eastern margin of the range is approached. North-facing or canyon slopes seldom support brush or woodland thickets as in the interior of the range. A sagebrush community, consisting of such species as *Artemisia californica*, which is usually dominant, *Eriogonum fasciculatum* var. *foliolosum*, *Malvastrum Fremontii* var. *cercophorum*, *Salvia mellifera*, and *Mimulus aurantiacus*, forms occasional islands in the grassland.

It is likely that the grassland of the extreme eastern side of the range was not formerly dominated by chaparral as postulated by Cooper (1922) for the interior and western sides of the range. This area closely approaches the climatic conditions of the San Joaquin Valley, where grassland is considered to

be the climax. Likewise, there are many species of desert affinities in this eastern foothill zone, such as *Prosopis chilensis*, *Oenothera deltoidea* var. *cognata*, *Nicotiana glauca*, *Amsinckia vernicosa*, *Plagiobothrys arizonicus*, *Salvia carduacea*, *Malacothrix Coulteri*, etc. Their presence indicates a close environmental relationship with the desert-like ridges which surround the southern end of the San Joaquin Valley where chaparral, according to Cooper, probably never controlled the present grassland areas. Even toward the interior of the range on this eastern side, a few typically desert species are found in the grassland, for example, *Eriophyllum Wallacei* and *Lepidospartum squamatum*.

A riparian community occurs along the perennial streams throughout the range, but is most highly developed on the western side, as for example, along Arroyo Hondo and its tributaries, Smith Creek and Santa Isabella Creek. In these areas, thick canopies of *Alnus rhombifolia*, *Acer macrophyllum*, *Arbutus Menziesii*, *Platanus racemosa*, and *Umbellularia californica* provide shaded niches for such mesophytic herbaceous species as *Adiantum Jordani*, *Cystopteris fragilis*, *Disporum Hookeri*, *Smilacina amplexicaulis*, *S. sessilifolia*, *Epipactis gigantea*, *Aquilegia Tracyi*, *Mimulus nasutus*, and *M. cardinalis*. Where the streams are intermittent, as they mainly are in the interior and on the eastern side of the range, the riparian community is much more limited and much less mesophytic, and scattered trees of *Salix laevigata*, *S. lasiolepis*, *Populus Fremontii*, or *Platanus racemosa*, together with certain species of *Carex* and *Juncus*, may represent the only definitely stream-side species.

If, in summary, a comprehensive picture of the vegetation is attempted,



Fig. 9. North end of Adobe Valley at eastern edge of Red Mountains; typical savannah in foreground, dense chaparral on background.

the major communities appear to be grassland and chaparral. On the western slope grassland usually predominates; in the interior of the range grassland or savannah are abundant, but chaparral covers large areas; on the eastern crest (Red Mountains) chaparral is the most extensive community, while in the eastern foothill belt grassland usually predominates. Thus, from the vegetational viewpoint, no one portion of the range is markedly diverse from any other portion; the several communities are repeated in various areas.

When the floristic content of the communities is considered, however, marked changes are seen to occur as one crosses the narrow axis of the range (i.e., latitudinally, or from west to east), so that four longitudinal floristic zones are evident: 1) a western zone which includes the western slope and crest of the range, 2) an interior zone, that area which lies between western and eastern crests, 3) the eastern crest (Red Mountains), 4) an eastern foothill zone. In part these floristic zones are controlled by topography and climate, the western zone containing the most mesophytic species, the eastern foothill zone containing the most xerophytic (here occur most of the Great Basin and desert derivatives discussed later). In the interior and especially in the Red Mountains, however, the influence of the soils and the long history of these regions as exposed and isolated land masses are both significant. It is here that most of the central Coast Range endemic species occur.

#### SEASONAL PERIODICITY

There is a seasonal periodicity involved in the development of the vegetation, with two well marked seasons of plant growth, vernal and aestival, each characterized by a different flora. The vernal flora is composed of many species of ephemeral annuals, the individual plants of which occur in great numbers and cover large areas of grassland throughout the range. The vernal flora is particularly well developed in valley areas in the interior of the range, such as Santa Isabella Valley and San Antonio Valley. It is also well developed in the eastern foothill zone. The life span of the vernal annuals is short, and is adapted to the period of moderate temperature which follows the late winter and early spring rains and precedes the aridity and high temperatures of summer. Flowering usually occurs in late March or early April. Such a vernal flora is typical of large areas in the grasslands of California. Some of the characteristic species in the Mount Hamilton Range are *Ranunculus californica*, *Athysanus pusillus*, *Eschscholtzia californica*, *Lupinus bicolor*, *Gilia tricolor*, *Nemophila Menziesii*, *Orthocarpus purpurascens*, *O. densiflorus*, *Achyrochaena mollis*, *Layia platyglossa*, *Coreopsis calliopsidea*, *Monolopia major*, etc.

The aestival flora is represented by a relatively few species of annuals, herbaceous perennials, or suffrutescent plants which are adapted to a highly xeric environment. The number of individuals produced, however, and the area covered, are large. Again the grasslands of the range are the major areas occupied. The aestival flora reaches its best development in the interior and on the eastern side of the range. Flowering usually occurs in late August and September during the period of highest temperatures and little or no rainfall.

Like the vernal flora, this aestival flora is characteristic of the grasslands of California. Typical species in the Mount Hamilton Range are *Eriogonum vimineum*, *E. virgatum*, *E. Wrightii*, *Eremocarpus setigerous*, *Grindelia camporum*, and various species of *Hemizonia*, *Calycadenia*, and *Madia*.

Although vernal and aestival seasons of plant growth are highly differentiated, by no means all species are adapted to one or the other of these seasonal patterns. Many species bloom mainly in late spring and early summer (May and June), although these are not so well represented as the vernal or aestival species, either from the standpoint of species involved, numbers of individuals, or the areas occupied. From a taxonomic and geographic viewpoint, however, many of the most distinctive species bloom in the late spring. These species are best developed in the interior and on the eastern side, and characteristic among them are: *Allium falcifolium*, *Eriogonum saxatile*, *Streptanthus callistus*, *Sedella pentandra*, *Clarkia Breweri*, *Oenothera decorticans* var. *typica*, *Sanicula saxatilis*, *Phacelia Breweri*, *Salvia Columbariae*, *Acanthomintha lanceolata*, *Castilleja Roseana*, *Malacothrix floccifera*, *Cirsium campylon*, etc.

#### Geographical Analysis of the Species

Although the vascular species of the Mount Hamilton Range comprise a relatively distinctive assemblage, over half being endemic to California, the flora is not a homogeneous one. Like all other "floras" it is composed of diverse floristic elements (groups of species), each homogeneous in that it has had a common center of origin and dispersal from which the component species migrated. These elements arose in response to certain physical and biological factors or interacting combinations of these factors, and the species within each element have a similar migrational history and a basically similar pattern of distribution. In reconstructing the geographical history of a flora, it should be theoretically possible to determine the composition, origin, and migration of each of its floristic elements. A more or less arbitrary disposition of many species is necessary, however, for paleontological evidence may be meager or lacking, many morphological and taxonomic affinities are obscure, genetic relationships are infrequently and incompletely known, distributional knowledge is seldom complete, and centers of origin and dispersal together with the areas of greatest differentiation are difficult to trace. Therefore the floristic elements, as recognized, do not represent completely homogeneous groups of species, and their true composition is only partly realized. With these points in mind, division of the Mount Hamilton Range flora into its component floristic elements may be attempted. Two groups of species of dubious history, and three floristic elements are considered in the following discussion. Because of the limits of knowledge concerning them, the elements, as presented, vary greatly in their homogeneity. Origin and migration of the species in each element are considered only where they aid directly in analyzing the flora of the Mount Hamilton Range.

#### COSMOPOLITAN SPECIES

A group of cosmopolitan species occurs in the Mount Hamilton Range, these species having a very broad climatic tolerance and being more or less world wide in distribution, at least as to the extratropical zones of the north-

ern hemisphere. The following list indicates the types of cosmopolitan species which occur in the Mount Hamilton Range, but is not intended to be a complete enumeration. Many of the species are of aquatic or semi-aquatic habitats. The origin and migration of these widely-distributed species is exceedingly difficult to trace, and the products of several floristic elements are probably represented. Species of this type are of little value in determining the history of a local flora such as that of the Mount Hamilton Range.

|                               |                                      |
|-------------------------------|--------------------------------------|
| <i>Cystopteris fragilis</i>   | <i>Juncus bufonius</i>               |
| <i>Equisetum arvense</i>      | <i>Montia fontana</i>                |
| <i>Zannichellia palustris</i> | <i>Spergularia saligna</i>           |
| <i>Alisma Plantago</i>        | <i>Ranunculus trichophyllus</i>      |
| <i>Phragmites communis</i>    | <i>Radicula Nasturtium-aquaticum</i> |
| <i>Hordeum nodosum</i>        | <i>Arabis glabra</i>                 |
| <i>Eleocharis mammillata</i>  | <i>Capsella procumbens</i>           |
| <i>Eleocharis acicularis</i>  | <i>Callitriche palustris</i>         |
| <i>Lemna minor</i>            | <i>Galium Aparine</i>                |
| <i>Juncus sphaerocarpus</i>   | <i>Artemisia Dracunculus</i>         |
| <i>Juncus balticus</i>        |                                      |

#### INTRODUCED SPECIES

Nine per cent of the Mount Hamilton Range flora consists of introduced or alien species. This includes both definitely established and merely adventive species. Their relative influence in competition with the native vegetation was discussed under the influence of man. These species may be European, Asiatic, or Australian in origin, and they compose a homogeneous group only in the sense that their history of migration and establishment in new areas is coincident with or follows that of man. They are not a part of the natural plant life of the Mount Hamilton Range. The known introduced species are:

|  |   |
|--|---|
| <i>Bromus rubens</i>                       | <i>Amaranthus blitoides</i>               |
| <i>Bromus rigidus</i>                      | <i>Clinus lotoides</i>                    |
| <i>Bromus mollis</i>                       | <i>Cerastium viscosum</i>                 |
| <i>Bromus arenarius</i>                    | <i>Stellaria media</i>                    |
| <i>Festuca dertonensis</i>                 | <i>Sagina apetala</i> var. <i>barbata</i> |
| <i>Poa annua</i>                           | <i>Herniaria cinerea</i>                  |
| <i>Poa pratensis</i>                       | <i>Silene gallica</i>                     |
| <i>Lamarckia aurea</i>                     | <i>Brassica campestris</i>                |
| <i>Hordeum murinum</i>                     | <i>Brassica arvensis</i>                  |
| <i>Hordeum gussoneanum</i>                 | <i>Brassica incana</i>                    |
| <i>Lolium multiflorum</i>                  | <i>Capsella Bursa-pastoris</i>            |
| <i>Avena fatua</i>                         | * <i>Prunus cerasifera</i>                |
| <i>Avena barbata</i>                       | * <i>Pyrus Malus</i>                      |
| <i>Agrostis verticillata</i>               | <i>Medicago lupulina</i>                  |
| <i>Polypogon lutosus</i>                   | <i>Medicago hispida</i>                   |
| <i>Polypogon monspeliensis</i>             | <i>Medicago apiculata</i>                 |
| <i>Gastidium ventricosum</i>               | <i>Melilotus alba</i>                     |
| <i>Urtica urens</i>                        | <i>Vicia sativa</i>                       |
| <i>Rumex crispus</i>                       | <i>Ceranium dissectum</i>                 |
| <i>Rumex conglomeratus</i>                 | <i>Erodium Botrys</i>                     |
| <i>Rumex acetosella</i>                    | <i>Erodium moschatum</i>                  |
| <i>Chenopodium album</i>                   | <i>Erodium cicutarium</i>                 |
| <i>Salsola Kali</i> var. <i>tenuifolia</i> | <i>Conium maculatum</i>                   |

\* = Sporadic escapes from cultivation, and not established.



*Anagallis arvensis*  
*Marrubium vulgare*  
*Lamium amplexicaule*  
*Nicotiana glauca*  
*Verbascum thapsus*  
*Plantago major*  
*Dipsacus Fullonum*  
*Hypochaeris glabra*

*Lactuca saligna*  
*Sonchus asper*  
*Xanthium spinosum*  
*Matricaria matricarioides*  
*Senecio vulgaris*  
*Cirsium lanceolatum*  
*Centaurea melitensis*

## NORTHERN FLORISTIC ELEMENT

At least fifteen per cent, probably a much larger proportion, of the Mount Hamilton Range species belong to the so-called "northern" floristic element of the California flora. These are species presumed to have had an origin in the north; or some may represent warm-temperate descendants of species which had a southern origin and spread north in the Eocene, later reinvading southern areas. During the middle of the Tertiary they formed a widespread, uniform flora over much of the northern portion of the northern hemisphere, this flora being known as the Miocene redwood forest of western North America. Southward migration and climatic segregation of these northern species began in the late Miocene and continued through progressive climatic changes to the end of the Tertiary, giving way to localized segregation in the Quaternary. The total composition of the northern floristic element in California is by no means fully known. Paleobotanical evidence has established the migrational history of the Miocene redwood forest, however, (Chaney, 1926) and a number of Mount Hamilton Range species are present-day equivalents of species which belonged to this redwood flora. In addition, many Mount Hamilton Range species not known to have equivalents in the redwood flora, including many species now restricted to California, are believed, on the basis of other criteria, to belong to the northern floristic element. Representative examples are:

*Torreya californica*  
*Scribneria Bolanderi*  
*Trillium sessile* var. *giganteum*  
*Disporum Hookeri*  
*Habenaria unalaschensis*  
*Alnus rhombifolia*  
*\*Polygonum Parryi*  
*Claytonia gypsophiloides*  
*Arenaria pusilla*  
*Umbellularia californica*  
*Berberis pinnata*  
*\*Paeonia Brownii*

*\*Isopyrum stipitatum*  
*Thalictrum polycarpum*  
*\*Platysperum scapigerum*  
*Ribes sanguineum* var. *glutinosum*  
*Prunus emarginata*  
*Rosa gymnocarpa*  
*Amelanchier alnifolia* var. *subintegra*  
*Trifolium cyathiferum*  
*Acer macrophyllum*  
*Arbutus Menziesii*  
*Crepis occidentalis* subsp. *pumila*  
*\*Crepis monticola*  
*\*Crocidium multicaule*

\* = Known southern limit in the Mount Hamilton Range.

Many of the northern species which occur in California have a relatively wide range of climatic tolerance, and are found throughout most of the state. Others, however, are limited mainly or entirely to the cool, humid climate of the North Coast Ranges. Some of these more restricted northern species occur in the outer South Coast Ranges, and a few also occur in portions of the warmer, more arid inner South Coast Ranges. One small although distinctive group of species from the preceding list is well represented in the North

Coast Ranges, although it occurs in the South Coast Ranges only in the Mount Hamilton Range. These species can be classed as "northern" with considerable assurance, although there is no paleobotanical evidence available that they belonged to the redwood flora. They are: *Scribneria Bolanderi*, *Polygonum Parryi*, *Arenaria pusilla*, *Paeonia Brownii*, *Platyspermum scapigerum*, *Trifolium cyathiferum*, *Crepis occidentalis* subsp. *pumila*, and *Crocidium multicaule*. *Eriogonum hirtiflorum*, *Isopyrum stipitatum*, *Viola Sheltonii*,<sup>3</sup> and *Crepis monticola*, although not found north of southern Oregon, appear to belong to this group as well. Stebbins (1938) and Babcock and Stebbins (1939), treating *Paeonia Brownii* and the two *Crepis* species respectively, consider these species to be reliquial in the Mount Hamilton Range, climate being the controlling factor in their persistence. It is possible that investigations may yield more or less similar interpretations for all the above species.

As to *Paeonia Brownii*, Stebbins believes it to represent a species which shows definite conservatism in the southern part of its range, where it is dying out due to the progressive advance of a warmer climate. Thus the Mount Hamilton Range locality represents the only known and presumably the last outpost of *P. Brownii* in the South Coast Ranges. As to the two *Crepis* species, Babcock and Stebbins consider the polyploid forms of these two heteroploid species to have a wide range of tolerance. The Mount Hamilton Range is a distant outpost for both, where they exist as single, static, apomictic forms, or biotypes, highly isolated from the centers of dispersal of the diploid sexual forms where new biotypes are being produced constantly. These two Mount Hamilton Range apomicts have survived on the distributional fringes of each species because their climatic tolerance was such as to permit them to survive under changing environmental conditions which eliminated the host of other biotypes. They are genetically depleted types, able to persist at their present outposts only so long as the environment remains favorable to their climatic tolerance (Stebbins, 1942).

In connection with the reliquial nature of *Paeonia Brownii* and *Crepis occidentalis* subsp. *pumila* in the Mount Hamilton Range, it is significant that both these species are represented in southern California by closely related but genetically distinct units. *Paeonia Brownii* is replaced there by *P. californica*, a species adapted to and advancing with the warmer, more arid climate of that area (Stebbins, 1938). *Crepis occidentalis* subsp. *pumila* is represented in southern California by an apomictic form related to Sierra Nevada rather than Coast Range biotypes, and thus with a different migrational history and range of tolerance than the Mount Hamilton plants (Babcock and Stebbins, 1939). Of the northern species being discussed, *Eriogonum hirtiflorum* is replaced in southern California by the closely related *E. inerne* which comes north as far as the Mount Hamilton Range (and Mount Diablo?). *Arenaria pusilla*, *Polygonum Parryi*, and *Trifolium cyathiferum* reappear in southern California, although highly localized. Presumably they are reliquial there and in the Mount Hamilton Range. On the other hand, cytogenetic study may indicate that, for these species as for the *Eriogonum*, *Paeonia*, and *Crepis* species, the

<sup>3</sup> Also found in one locality on Mount Diablo.

southern California and Mount Hamilton Range plants represent different genetical strains adapted to different climatic conditions.

#### SONORAN FLORISTIC ELEMENT

Certain species, here designated as the Sonoran floristic element, are also known in the California literature as the Sierra Madrean element (Axelrod, 1939), the Californian element, the southern or austral element, or the southwestern element, each of these names representing slightly different points of view as to origin and history of the species involved. As with the northern element, complete knowledge of the composition of the Sonoran floristic element in the California flora is lacking. Less paleobotanical evidence is available upon which to establish the origin and migrational history of this element than for the northern element, although recent papers by Axelrod (1938, 1939) concern it and its segregational products. According to Axelrod, this element arose in the Sierra Madre area of northern Mexico during the Oligocene, and migrated northward along arid, upland routes in the Miocene and later Tertiary in response to the progressive aridity of the climate in northern Mexico, southwestern United States, and southeastern California. It was more continental in climatic requirements than the northern element, and consequently was quite widely separated from the latter during the Miocene. Invasion of the lowland and northern areas was not effected to any extent until the dryer climate of the Pliocene made this possible. The modern representatives of this flora have their present centers of distribution largely in northern Mexico and the southwestern United States, but extend north over the Columbia Plateau, east to Oklahoma, and west to California. The Great Basin and desert species which enter California are probably segregates of the Sonoran floristic element, as well as many species now restricted to California. The Californian derivatives are concentrated in desert and cismontane areas of southern California, but many extend north to central or even northern California, or are now limited to areas north of southern California. The Californian derivatives constitute the "Californian element" of Axelrod (1939). He regards them as a segregation product of the Sonoran floristic element, which became predominant in southeastern California in the late Pliocene following climatic changes that involved a shift in seasonal rainfall from summer to winter months.

Following is a representative list of Mount Hamilton Range species believed to have arisen from the Sonoran floristic element:

|                                 |   |
|---------------------------------|---|
| <i>Selaginella Bigelovii</i>    | <i>Allium Parryi</i>                          |
| * <i>Pinus Coulteri</i>         | <i>Allium peninsulare</i> var. <i>crispum</i> |
| * <i>Juniperus californicus</i> | <i>Muilla serotina</i>                        |
| <i>Stipa pulchra</i>            | <i>Calochortus invenustus</i>                 |
| <i>Stipa lepida</i>             | <i>Calochortus clavatus</i>                   |
| <i>Puccinellia simplex</i>      | <i>Quercus Douglasii</i>                      |
| <i>Allium fimbriatum</i>        | * <i>Quercus dumosa</i>                       |
| <i>Allium lacunosum</i>         | * <i>Quercus chrysolepis</i>                  |

\* = Species with known fossil records or for which equivalent species are known in the fossil record.

- \*Salix lasiolepis*  
*\*Populus Fremontii*  
*Chorizanthe perfoliata*  
*Chorizanthe polygonoides*  
*Chorizanthe Clevelandii*  
*Chorizanthe uniaristata*  
*Eriogonum nudum* var. *auriculatum*  
*Eriogonum virgatum*  
*Eriogonum saxatile*  
*Eriogonum fasciculatum* var. *foliosum*  
*Eriogonum Wrightii*  
*Atriplex Serenana*  
*Calyptridium monandrum*  
*Calyptridium Parryi*  
*Umbellularia californica*<sup>4</sup>  
*Delphinium Parryi*  
*Papaver heterophyllum*  
*Tropidocarpum gracile*  
*Streptanthus Coulteri* var. *Lemmonii*  
*Lithophragma Cymbalaria*  
*Ribes quercetorum*  
*Ribes aureum* var. *gracillimum*  
*Ribes malvaceum*  
*Ribes amarum*  
*Ribes speciosum*  
*\*Platanus racemosa*  
*\*Photinia arbutifolia*  
*\*Cercocarpus betuloides*  
*\*Holodiscus discolor*  
*Prunus ilicifolia*  
*\*Prosopis chilensis*  
*Lotus strigosus*  
*Lotus scoparius*  
*Astragalus didymocarpus*  
*Astragalus oxyphrys*  
*\*Rhamnus californica*  
*\*Ceanothus cuneatus*  
*Ceanothus Ferrisae*  
*Mentzelia gracilentia*  
*Oenothera micrantha* var. *Jonesii*  
*Oenothera contorta* var. *strigulosa*  
*Lomatium dasycarpum*  
*Arbutus Menziesii*<sup>4</sup>  
*\*Arctostaphylos glauca*  
*Forestiera neomexicana*
- \*Fraxinus dipetala*  
*Hugelia pluriflora*  
*Hugelia filifolia* var. *typica*  
*Gilia multicaulis*  
*Pholistoma aurita*  
*Pholistoma membranacea*  
*Lemmonia californica*  
*Eucrypta chrysanthemifolia*  
*Emmenanthe penduliflora* and var. *rosea*  
*Phacelia ramosissima* var. *suffrutescens*  
*Pectocarya linearis* var. *ferocula*  
*Pectocarya setosa*  
*Amsinckia Eastwoodae*  
*Amsinckia vernicosa*  
*Amsinckia tessellata*  
*Cryptanthe Clevelandii*  
*Cryptanthe corollata*  
*Salvia mellifera*  
*Salvia carduacea*  
*Mimulus androsaceus*  
*Lonicera Johnstoni*  
*Lonicera interrupta*  
*Nemacladus ramosissimus*  
*Stephanomeria exigua* var. *coronaria*  
*Malacothrix Coulteri*  
*Malacothrix Clevelandii*  
*Gutierrezia californica*  
*Stenolopsis linearifolius*  
*Eastwoodia elegans*  
*Chrysothamnus nauseosus* var. *mohavensis*  
*Chrysopsis villosa* vars.  
*Lessingia germanorum* var. *parvula*  
*Corethrogyne filaginifolia*  
*Stylocline filaginifolia*  
*Coreopsis calliopsidea*  
*Coreopsis Douglasii*  
*Coreopsis hamiltonii*  
*Hemizonia Kelloggii*  
*Hemizonia fasciculata*  
*Monolopia major*  
*Eriophyllum Wallacei*  
*Artemisia californica*  
*Senecio Breweri*  
*\*Lepidospartum squamatum*

<sup>4</sup> Species listed in "northern" element as well; presumably with a southern origin, migrating north in the Eocene to become elements in the Miocene redwood forest and to migrate south again.

#### GREAT BASIN AND DESERT DERIVATIVES

Many Great Basin and desert derivatives of the Sonoran floristic element are entirely restricted, in California, to the desert areas. Some, however, have a sufficiently broad range of climatic tolerance to allow for limited establishment westward beyond the desert areas, or they may be replaced there by closely related species. The major area where such species occur is the foothill zone which encircles the head of the San Joaquin Valley (Fig. 3). This

includes the Kern basin area at the southwestern margin of the Sierra Nevada, the northern base of the Tehachapi Mountains, and the eastern base of the inner South Coast Ranges (Temblor and Diablo ranges). The species of this group which reach the Diablo Range are usually restricted to a few isolated localities. In the Mount Hamilton Range these species form a small but highly distinctive unit of the flora. A list of them is given below. Their Great Basin and desert affinities are evident by even a casual perusal of the list.

|   |   |
|---|---|
| <i>Juniperus californicus</i>                     | * <i>Phacelia Fremontii</i>                             |
| <i>Puccinellia simplex</i>                        | <i>Lemmonia californica</i>                             |
| <i>Allium fimbriatum</i>                          | <i>Emmenanthe penduliflora</i> var. <i>rosea</i>        |
| * <i>Allium peninsulare</i> var. <i>crispum</i>   | <i>Pectocarya setosa</i>                                |
| <i>Allium lacunosum</i>                           | <i>Amsinckia grandiflora</i>                            |
| <i>Chorizanthe uniaristata</i>                    | * <i>Amsinckia vernicosa</i>                            |
| <i>Chorizanthe Clevelandii</i>                    | * <i>Amsinckia tessellata</i>                           |
| * <i>Chorizanthe perfoliata</i>                   | <i>Cryplanthe nevadensis</i> var. <i>rigida</i>         |
| <i>Eriogonum angulosum</i>                        | * <i>Plagiobothrys arizonicus</i>                       |
| * <i>Calyptridium monandrum</i>                   | <i>Salvia carduacea</i>                                 |
| <i>Streptanthus Coulteri</i> var. <i>Lemmonii</i> | * <i>Monardella Breweri</i>                             |
| <i>Streptanthus lilacinus</i>                     | <i>Malacothrix Coulteri</i>                             |
| <i>Tropidocarpum capparideum</i>                  | * <i>Eastwoodia elegans</i>                             |
| * <i>Prosopis chilensis</i>                       | * <i>Chrysothamnus nauseosus</i> var. <i>mohavensis</i> |
| * <i>Astragalus oxyphysis</i>                     | * <i>Coreopsis calliopsidea</i>                         |
| <i>Euphorbia ocellata</i>                         | * <i>Coreopsis hamiltonii</i>                           |
| * <i>Malvastrum Parryi</i>                        | * <i>Coreopsis Douglasii</i>                            |
| * <i>Oenothera deltooides</i> var. <i>cognata</i> | * <i>Hemizonia pungens</i>                              |
| * <i>Oenothera decorticans</i> var. <i>typica</i> | <i>Madia radiata</i>                                    |
| <i>Forestiera neomexicana</i>                     | * <i>Eriophyllum Wallacei</i>                           |
| * <i>Hugelia pluriflora</i>                       | <i>Senecio Breweri</i>                                  |
| * <i>Pholistoma membranacea</i>                   | * <i>Lepidospartum squamatum</i>                        |

\* Northern limit in Mount Hamilton Range.

These species are restricted almost entirely to the eastern margin of the Mount Hamilton Range, although a few are found in the interior (*Juniperus californicus*, *Chorizanthe perfoliata*, *Forestiera neomexicana*, *Coreopsis Douglasii*, *Eriophyllum Wallacei*, *Senecio Breweri*, *Lepidospartum squamatum*) or on the summit areas of the western crest (*Calyptridium monandrum*, *Chrysothamnus nauseosus* var. *mohavensis*, *Coreopsis hamiltonii*), but none reaches the more mesophytic western slopes of the range.

Over half of the species listed have their known northern limit in the Mount Hamilton Range. This large percentage is understandable on the basis of the presumed origin, migrational history, and environmental requirements of the group as a whole. As to origin, the Miocene Tehachapi flora described by Axelrod (1939) possesses fossil representatives of modern species whose distributional pattern coincides with that of the species in question—the Great Basin, desert regions of California, southern Sierra Nevada, and inner South Coast Ranges. On the basis of their fossil equivalents, the modern species are considered by Axelrod to have arisen in the Sierra Madre of northern Mexico, and thus they are members of the Sonoran (Sierra Madrean) floristic element. It is logical to assume that, even when fossil equivalents are lacking, modern species with a similar distribution to the above have a similar origin.

Considering migrational history next, the Walker Pass (oral communication, H. L. Mason in 1939), and to a lesser degree the Tehachapi Pass and the Tejon Pass (Parish, 1903, 1930), form the principal gateways for the migration of the typically desert species from the western margin of the Mohave Desert into the foothill zone at the head of the San Joaquin Valley (Fig. 3). The elevation here is much lower (400-1000 feet) than in the western part of the Mohave Desert (2700-3000 feet), although the temperature extremes are slightly less and the precipitation is slightly more (5.72 inches at Bakersfield, 4.86 inches at Mohave). The environment is sufficiently desert-like, however, to permit the establishment of certain desert species. According to Bauer (1930), the northern base of the Tehachapi Mountains at the extreme head of the San Joaquin Valley constitutes a "semi-desert." Paleobotanical evidence indicates that migration into these areas did not become definitely established until the late Pliocene, and presumably most of it has occurred subsequent to the post-Pleistocene development of a sufficiently warm, arid climate in these extra-desert areas.

Climatic conditions comparable to those at the head of the San Joaquin Valley prevail along the eastern margin of the inner South Coast Ranges, permitting the northward migration and establishment of some of the more tolerant desert species. The climate undergoes a gradual but progressive northward moderation, however, the temperature extremes lessening and the rainfall increasing, and coincident with these climatic changes there is a gradual dropping out of the desert species, so that the farther north one progresses, the fewer are found. The eastern side of the Mount Hamilton Range represents the last extensive area favorable to typically desert species. This accounts for the large number of these species which have their northern outpost in the Mount Hamilton Range. A few reach their northern limit on Mount Diablo or in the region east of Mount Diablo (*Eriogonum angulosum*, *Forestiera neomexicana*, *Salvia carduacea*, *Malacothrix Coulteri*, *Madia radiata*, *Senecio Breweri*), and at least four (*Juniperus californicus*, *Allium fimbriatum*, *Chorizanthe Clevelandii*, and *Lemmonia californica*) are found in the "hot-summer" climatic zone which occurs in the vicinity of Lake County of the North Coast Ranges. Thus the extra-desert distributional pattern of these desert species can be likened to a gradually tapering inverted V, the base of which is curved and lies in the northern foothills of the Tehachapi Mountains, while the extreme apex extends approximately to Lake County in the North Coast Ranges. Climate is the major factor controlling the extra-desert migration and establishment of these species, as it is likewise the major controlling factor in their gradual northward restriction.

In certain of the species, however, the edaphic factor appears to exert a secondary influence on distribution, as in *Allium fimbriatum* and *Emmenanthe penduliflora* var. *rosea*. In the Mount Hamilton Range both of these species are restricted to the serpentine areas of the Red Mountains. The limited occurrence of *Allium fimbriatum* in the inner South Coast Ranges and its long "jump" from the Mount Hamilton Range to the serpentine areas of Lake

County in the North Coast Ranges may be partly the result of an edaphic limitation to serpentine soils. *Allium lacunosum* is similarly, although less strongly, influenced in its distribution by the occurrence of serpentine soils.

Some of the Great Basin and desert derivatives listed do not occur in the desert areas, but are restricted to a larger or smaller portion of the foothill zone of the San Joaquin Valley. These are *Chorizanthe uniaristata*, *C. Clevelandii*, *Streptanthus Coulteri* var. *Lemmonii*, *S. lilacinus*, *Tropidocarpum capparideum*, *Astragalus oxyphysus*, *Malvastrum Parryi*, *Oenothera decorticans* var. *typica*, *O. deltoidea* var. *cognata*, *Hugelia pluriflora*, *Emmenanthe penduliflora* var. *rosea*, *Amsinckia grandiflora*, *Eastwoodia elegans*, *Senecio Breweri*, *Coreopsis hamiltonii*, and *Coreopsis Douglasii*. They are associated with typically desert species both distributionally and taxonomically, however, as the following examples suggest:

## Extra-desert species

*Streptanthus Coulteri* var. *Lemmonii*  
*Oenothera decorticans* var. *typica*

*Oenothera deltoidea* var. *cognata*  
*Emmenanthe penduliflora* var. *rosea*  
*Coreopsis hamiltonii*  
*Coreopsis Douglasii*

## Typically desert species

*Streptanthus Coulteri*  
*O. decorticans* (vars. *rutilla*, *desertorum*,  
*condensata*)  
*O. deltoidea*  
\**Emmenanthe penduliflora*  
*C. Bigelovii*  
\**C. californica*

\* = Also well developed in cismontane southern California.

*Coreopsis hamiltonii*-*C. Bigelovii* and *C. Douglasii*-*C. californica* form two such instances of close distributional and taxonomic relationships (Sharsmith, 1938). *Coreopsis hamiltonii* has somewhat less arid and hot climatic requirements than the typically desert species, *C. Bigelovii*, and is known only from the Mount Hamilton Range, although its morphology suggests it to be closely related to and a derivative of the desert species, *C. Bigelovii*. Similarly, *C. Douglasii* is known only from the inner South Coast Ranges, but it is closely related to and considered to have been derived from *C. californica* of the desert and cismontane areas of southern California.

## CISMONTANE SOUTHERN CALIFORNIA DERIVATIVES

Another group of derivatives of the Sonoran floristic element is closely related to the typically desert species just considered. It consists of species which have their centers of distribution in northern Baja California and cismontane southern California or which have their affinities in these areas, but which are presumed to have been derived from the Sonoran floristic element. They occur northward in the South Coast Ranges approximately to central California and may occur northward in the southern Sierra Nevada as well. A representative list of these Mount Hamilton Range species is:



- \**Selaginella Bigelovii*
- Pinus Coulteri*
- Stipa pulchra*
- Stipa lepida*
- \**Allium Parryi*
- \**Muilla serotina*
- \**Calochortus invenustus*
- Calochortus clavatus*
- Chorizanthe polygonoides*
- Eriogonum virgatum*
- \**Eriogonum saxatile*
- \**Eriogonum fasciculatum* var. *foliolosum*
- \**Calyptidium Parryi*
- \**Delphinium Parryi*
- Papaver heterophyllum*
- Tropidocarpum gracile*
- \**Lithophragma Cymbalaria*
- Ribes aureum* var. *gracillimum*
- Ribes malvaceum*
- \**Ribes quercolorum*
- Ribes amarum*
- \**Ribes speciosum*
- Prunus ilicifolia*
- Lotus strigosus*
- Lotus scoparius*
- Astragalus didymocarpus*
- Mentzelia gracilentia*
- Oenothera micrantha* var. *Jonesii*
- Oenothera contorta* var. *strigulosa*
- Lomatium dasycarpum*
- Arctostaphylos glauca*
- Hugelia filifolia* (var. *typica*)
- Gilia multicaulis*
- Pholistoma aurita*
- Eucrypta chrysanthemifolia*
- \**Phacelia ramosissima* var. *suffrutescens*
- Pectocarya linearis* var. *serocula*
- Amsinckia Eastwoodae*
- Cryptanthe Clevelandii*
- \**Cryptanthe corollata*
- Salvia mellifera*
- \**Mimulus androsaceus*
- \**Lonicera Johnstoni*
- \**Nemacladus ramosissimum*
- \**Stephanomeria exigua* var. *coronaria*
- Malacothrix Clevelandii*
- Gutierrezia californica*
- Stenotopsis linearifolius*
- Chrysopsis villosa* var.
- Lessingia germanorum* var. *parvula*
- Corethrogyne filaginifolia*
- Stylocline gnaphaloides*
- Hemizonia Kelloggii*
- Hemizonia fasciculata*
- Artemisia californica*

\* = Northern limit in or approximately at the Mount Hamilton Range.

As with the typically desert species, climate is assumed to be the major limiting factor in the northward distribution of these typically cismontane southern California species. They form part of a larger number of species whose climatic tolerance entirely limits them to cismontane southern California. The species being considered are assumed to have a sufficiently broader range of climatic tolerance, however, to allow for their limited northward establishment. In the Coast Ranges this is mainly in the inner South Coast Ranges, although some may occur on the eastern slopes of the outer South Coast Ranges. In the Mount Hamilton Range, they may be found in all regions except the more highly mesophytic portions of the western slopes, although the greater number occurs only in the interior of the range.

As with the typically desert species, the Mount Hamilton Range forms the northern limit for many of these species, probably because it is the last site climatically favorable to their northward establishment. Several species are found northward beyond the Mount Hamilton Range only to Mount Diablo (*Pinus Coulteri*, *Ribes amarum*, *Arctostaphylos glauca*, *Eucrypta chrysanthemifolia*, *Salvia mellifera*, *Stenotopsis linearifolius*), while a few are found in the zone of "hot-summer" climate which occurs in the vicinity of Lake County in the inner North Coast Ranges (*Papaver heterophyllum*, *Hugelia filifolia* var. *typica*, *Gilia multicaulis*).

Again, as with the typically desert species, the edaphic factor appears to represent a limiting influence secondary to climate in the northward distribu-

tion of some of these typically cismontane southern California species. For example, in the Mount Hamilton Range, *Allium Parryi*, like *A. fimbriatum* of the preceding group, occurs only in the serpentine areas of the Red Mountains, and its highly restricted occurrence in the South Coast Ranges may be partly the result of an edaphic limitation to serpentine soils.

#### CENTRAL COAST RANGE ENDEMIC ELEMENT

The Mount Hamilton Range is characterized by a fairly high percentage (approximately 13 per cent) of species and varieties endemic to the Coast Ranges of California, of which about 3 per cent are limited to the central Coast Ranges. The latter are highly restricted in distribution, and are spoken of here as "narrow" endemics, although such a classification is, of course, relative. On the basis of their morphology, distribution, and taxonomic affinities, many of the Coast Range endemics of the Mount Hamilton Range can be considered as depleted species, once of wider distribution, which have an origin and history in common with either the northern or the Sonoran floristic elements. Where the evidence indicated this, such Coast Range endemics were included in one or the other of these elements. Thus, under the northern element, these Coast Range endemics were included: *Claytonia gypsophiloides*, *Berberis pinnata*, *Ribes sanguineum* var. *glutinosum*, and *Amelanchier alnifolia* var. *subintegra*. Under the Sonoran element, these Coast Range endemics were included: *Chorizanthe Clevelandii*, *C. uniaristata*, *Eriogonum nudum* var. *auriculatum*, *Streptanthus Coulteri* var. *Lemmonii*, *Oenothera contorta* var. *strigulosa*, *Lonicera interrupta*, *Coreopsis hamiltonii*, and *C. Douglasii*.

Many of the highly restricted and discontinuously distributed central Coast Range endemic species have an insular origin; that is, they are species which, by one means or another, became established on the Coast Range archipelago, where their continued isolation led to genetic uniformity and to distinction from the ancestral stocks. The origin and nature of insular species of this type is discussed by Stebbins (1942) in a paper which considers the problem of endemic species from the genetic viewpoint. The Mount Hamilton Range species of presumed insular origin are listed below, together with a condensed statement of the areas they occupy:

- Allium falcifolium*.<sup>5</sup> Eastern summits of Santa Cruz Mountains; Mount Hamilton Range; Mount Diablo; Sonoma County to southern Oregon.  
*Fritillaria folcata*. Mount Hamilton Range; San Carlos Range.  
*Salix Breweri*. San Carlos Range; Mount Hamilton Range; Napa, Lake, and Colusa counties of North Coast Ranges.  
*Eriogonum Covilleum*. San Carlos Range; Mount Hamilton Range.  
*Arenaria Douglasii* var.<sup>6</sup> Mount Hamilton Range.  
*Delphinium californicum* var. *interius*. Mount Hamilton Range; Mount Diablo.  
*Arabis Breweri*. Santa Cruz Mountains; Mount Hamilton Range; Mount Diablo; Lake and Napa to Siskiyou counties in North Coast Ranges.

<sup>5</sup> Not strictly a central Coast Range endemic species, and not in its entirety an insular species. Its segregate, *Allium Breweri* (Mount Diablo, Mount Hamilton Range, eastern summits of Santa Cruz Mountains), here considered conspecific with *A. falcifolium*, appears to have an insular history and may be genetically distinct.

<sup>6</sup> See page 337.

- Streptanthus albidus*. Mount Hamilton Range; Mount Diablo.
- Streptanthus Breweri*. San Carlos Range; Mount Hamilton Range; Glenn and Lake counties in North Coast Ranges.
- Streptanthus callistus*. Mount Hamilton Range.
- Linum Clevelandii*. Red Mountains of Mount Hamilton Range; Napa, Lake, and Mendocino counties in North Coast Ranges.
- Sedella pentandra*. Gavilan Range; San Carlos Range; Mount Hamilton Range; Lake County of North Coast Ranges.
- Trifolium dichotomum* var. *turbinatum*. Mount Hamilton; Mount St. Helena and Mount Tamalpais in North Coast Ranges.
- Lotus rubriflorus*. Mount Hamilton Range.
- Lathyrus Bolanderi* var. *quercetorum*. Mount Hamilton Range; Mount Diablo.
- Clarkia Breweri*. Mount Hamilton Range; eastern side Santa Cruz Mountains; San Carlos Range; Mayacamas Range, Sonoma County, in North Coast Ranges.
- Sanicula saxatilis*. Mount Hamilton; Mount Diablo.
- Garrya Congdoni*.<sup>7</sup> San Carlos Range; Mount Hamilton Range; Tehama and Lake counties in North Coast Ranges.
- Collomia diversifolia*. Mount Hamilton Range; Lake County in North Coast Ranges.
- Navarretia Abramsii*. Mount Hamilton Range; eastern side Santa Cruz Mountains; Lake County in North Coast Ranges.
- Linanthus ambiguus*. Mount Hamilton Range; eastern slopes Santa Cruz Mountains; Mount Diablo.
- Phacelia Breweri*. Gavilan Range; San Carlos Range; eastern side Santa Cruz Mountains; Mount Hamilton Range; Mount Diablo.
- Phacelia phacelioides*. Mount Hamilton Range; Mount Diablo.
- Acanthomintha lanceolata*. Eastern slopes Santa Cruz Mountains; Mount Hamilton Range.
- Castilleja Roseana*. San Carlos Range; Mount Hamilton Range.
- Campanula exigua*. Mount Hamilton Range; Mount Diablo.
- Eriophyllum Jepsonii*. San Carlos Range; Mount Hamilton Range; Mount Diablo.
- Cirsium campylon*. Mount Hamilton Range.

The origin and migrational history of these insular species is correlated with the geologic history of the Coast Ranges, and with the edaphic and climatic factors of the habitats which have been imposed upon them in consequence of their geologic history. As to geologic history first, not only are these endemics restricted to the central Coast Ranges, but their strikingly interrupted pattern of distribution coincides almost exactly with those portions of the Coast Ranges which are composed of the Franciscan rock series (Fig. 2).<sup>8</sup> The present exposure of Franciscan rocks in the South Coast Ranges, and presumably in the North Coast Ranges as well, corresponds to those areas which have been insular land masses since post-Jurassic times. These species, then, may be viewed as insular species restricted essentially to the emergent areas of Franciscan rock they occupied during the various periods of coastal inundation, particularly during the Pliocene-Pleistocene revolution when the Coast Ranges represented an archipelago system.

<sup>7</sup> Also in central Sierra Nevada in areas of the Mariposa rock series, a series homologous to the Franciscan series in the Coast Ranges.

<sup>8</sup> The observations recorded by Greene (1893b) of a north-south trend in the distribution of rare central California species are of interest here.

Jepson (1925) calls species of this sort insular relicts. He lists *Allium Breweri*,<sup>9</sup> *Streptanthus hispidus*,<sup>10</sup> *Sanicula saxatilis*, *Phacelia phacelioides*, possibly *Phacelia Breweri*, and *Campanula exigua* as "survivals on the mountain peaks of the central Coast Ranges, that is, the summit areas of Mount St. Helena, Mount Diablo, Mount Hamilton and Loma Prieta." As already discussed, however, not only the mountain peaks, but most of the surface area of the Mount Hamilton Range, the area now covered by Franciscan rocks, escaped invasion by the sea; correlated with this we find these species not localized on the mountain summits, but restricted to areas of Franciscan rock. Thus *Phacelia Breweri* and *Campanula exigua* occur across the Mount Hamilton Range in localized colonies from altitudes of 1000 to 4200 feet. *Phacelia phacelioides* occurs in the interior at 2000 feet altitude. Also, if these species are true insular species, their distribution has always been restricted to the island areas occupied, and they are not relicts in the sense that they were once more widespread.

These insular species are insular not only by virtue of their restriction to areas which once represented actual islands, but they are also insular in the sense that they are edaphically isolated. Their edaphic isolation rests upon the fact that they are restricted to areas of Franciscan rocks. As we have seen, the island areas and the Franciscan rock areas are coincident, and it was the actual island areas exposed during marine inundations which primarily imposed upon these species their limitation to Franciscan rocks. Secondarily, however, the distinctive soils of the Franciscan rocks must also have been a factor in the differentiation of the original insular plant populations from the continental ancestors; and later, when the seas withdrew, these soils must also have been a factor in preventing any appreciable migration beyond the original island boundaries.

Particularly in the case of serpentinophilous species, the evidence for edaphic control is striking. *Fritillaria folcata* has been found only on serpentine talus, in the Red Mountains of the Mount Hamilton Range and on San Benito Peak of the San Carlos Range. Related species, *F. glauca* and *F. Purdyi*, are limited species found only on serpentine in the Lake County area and somewhat north in the North Coast Ranges. *Cirsium campylon* is found only in the Mount Hamilton Range and only on serpentine soils. Its only close relative, *C. fontinale*, is an insular endemic of the outer Coast Ranges, restricted entirely to serpentine. *Salix Breweri*, *Streptanthus Breweri*, *Linum Clevelandii*, *Garryi Congdoni*, and *Collomia diversifolia* are found only on serpentine in the Mount Hamilton Range, and as far as is known, they are obligate to serpentine elsewhere. These latter species are not found between the serpentine of Lake County and the Mount Hamilton Range, and the edaphic factor evidently exerts an important control in their present discontinuous and limited distribution.

<sup>9</sup> See *Allium falcifolium*, preceding list.

<sup>10</sup> Only on Mount Diablo according to J. L. Morrison (oral communication in 1939).

Other of the central Coast Range insular endemics show a similar restricted and disjunct distribution. Although not limited to serpentine, *Clarkia Breweri*, *Navarretia Abramsii*, and *Sedella pentandra*, for example, have the same distribution as the obligate serpentine species, and do not occur between the Mount Hamilton Range and the Lake County Franciscan area of the inner North Coast Ranges (vicinity of Clear Lake, Fig. 2). This latter area includes southern Lake County and adjacent portions of Napa, Sonoma, Glenn, and Colusa counties. The distinction of the flora of this area from surrounding portions of the North Coast Ranges was pointed out by Jepson many years ago (1893).

North of this Lake County Franciscan area in the North Coast Ranges, the Franciscan rocks continue for a considerable distance, and the question arises as to why most of the disjunct species which occur both in the Mount Hamilton Range and in the Lake County area do not continue northward in the inner North Coast Ranges. Both climatic and edaphic controls are apparently involved. Edaphic control seems to be due to a gradual change north of Lake County in the nature of the Franciscan rocks, and the resultant change in character of the soils produced, whereas in the Lake County area where the species under consideration appear, the Franciscan rocks are much like those of the Mount Hamilton Range and produce the same types of soils. As to climate, most of the disjunct species seem to be limited to areas of hot-summer "olive" climate, and this is the type of Mediterranean climate found both in the Lake County area and throughout the interior of the Mount Hamilton Range, whereas north of Lake County the inner North Coast Ranges are predominantly in a cool-summer "heather" climate.

This restriction to areas of hot-summer "olive" climate also appears to be the reason why many of the disjunct species, including the obligate serpentine dwellers, occur both in the Lake County area and in the Mount Hamilton Range, but "skip" the intervening areas of Franciscan rock which appear on the summit of Mount Diablo and in the Contra Costa Hills. The summit of Mount Diablo has a cool-summer "heather" climate like that of the inner North Coast Ranges north of Lake County, while the Franciscan area of the Contra Costa Hills approaches a maritime climate due to its position near San Francisco Bay.

Some of the endemic species (*Arabis Breweri*, *Linanthus ambiguus*, *Phacelia phacelioides*, *P. Breweri*, and *Campanula exigua*) are limited to a cool-summer "heather" climate or have a climatic tolerance sufficient to account for their presence in both cool-summer and hot-summer types of Mediterranean climate. These species occur both on Mount Diablo and in the Mount Hamilton Range. The very distinctive and extremely narrow endemic, *Sanicula saxatilis*, is limited to several isolated colonies on the upper slopes of Mount Diablo and Mount Hamilton in the cool-summer zone of the higher altitudes. Climate also furnishes a clue why most of the Mount Hamilton Range insular species occur only in the inner Coast Ranges and not in the outer, for the climate of the outer Coast Ranges is considerably more maritime. Closely related but distinct species may occur on the insular areas of the outer and

inner Coast Ranges. *Campanula exigua*, for example, is represented by a closely related species, *C. angustiflora*, on the Franciscan rocks of Mount Tamalpais (outer North Coast Ranges) and Mount St. Helena (inner North Coast Ranges). The morphological divergence of these two units may be explained in part by the climatic divergence in the different insular areas occupied. Similar cases are those of *Cirsium campylon* and *Castilleja Roseana*. *Cirsium campylon*, an obligate serpentine species, has been discussed. *Castilleja Roseana*, found only in the Mount Hamilton Range and the San Carlos Range, finds its closest relative in the common and strictly maritime species, *C. latifolia*, of the outer Coast Ranges.

In review, the geologic history and the edaphic and climatic conditions of the Franciscan land masses have been considered as interacting factors involved in varying degree in the origin and distributional history of the central Coast Range species restricted to these areas. From the viewpoint of geologic history of the areas occupied, these species have been designated as insular endemics. It is assumed that these species or their precursors migrated into the central Coast Ranges from both northern and southern sources during the early Tertiary. Their subsequent long and isolated history on the insular land masses of the Coast Ranges, under the influence of distinctive edaphic conditions, has resulted in differentiation from the parental stocks, so that they now represent a separate unit in the California flora. Their long isolation resulted, especially for those species restricted to a single island area, in relatively non-plastic species with specialized edaphic requirements and a rather narrow range of climatic tolerance, so that in the post-Pleistocene period of coastal emergence they were unable to migrate appreciably beyond the Franciscan land blocks.

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### Annotated List of Vascular Species

The species of vascular plants known to occur in the Mount Hamilton Range are listed in the following pages. Careful taxonomic evaluation of these species was considered vital, for upon such evaluation rests the validity of the conclusions advanced to explain the geographical affinities of the flora. Determinations were checked by specialists wherever possible. For a number of the species, especially those of limited distribution, a considerable sum of new information, both morphological and distributional, was accumulated during the writer's field and herbarium work. Some of it has already been published by the writer and others, but any previously unpublished new material is included in this list. There is only one new entity, a variety, described herein (p. 337), but four species have been described in separate papers: *Lotus rubriflorus* (Sharsmith, Madroño 6:56. 1941), *Sedella pentandra* (Sharsmith, Madroño 3:240. 1936), *Cirsium campylon* (Sharsmith, Madroño 5:85. 1939), and *Streptanthus callistus* (Morrison, Madroño 4:205. 1938).

Specimens from the following herbaria are cited in the annotated list: California Academy of Sciences (CA), Gray Herbarium (G), Missouri Botanical Garden (Mo), Royal Botanic Gardens, Kew (K), Pomona College (P), Stanford University (S), State College of Washington (WSC), University of California (UC), and Vegetative Type Map Herbarium of the California Forest and Range Experiment Station (VTM).

In using monographic treatments it was the policy, in general, to accept the taxonomic treatment of the monographer concerned. This accounts for the interchangeable use, in some cases, of the categories of "variety" and "sub-

species." Synonyms (in italics and parentheses) are usually given only if they represent binomials accepted in current manuals or in other botanical literature which refers to the Mount Hamilton Range. The habitat and distribution of each species is given, and distribution is so stated as to give the occurrence of the species *across* the range from west to east, for, as discussed, the major floristic changes are met with latitudinally. Specimens are cited only for range extensions, rare species, or species involving a taxonomic problem. Types or isotypes which have been examined by the writer are designated by the symbol !. Introduced species are indicated by an asterisk. New names or combinations are printed in bold face. All localities cited are included in Figure 1.

## POLYPODIACEAE

*CYSTOPTERIS FRAGILIS* (L.) Bernh. (*Filix fragilis* (L.) Gilib.) Sheltered ravines and wooded slopes, west side Mount Hamilton.

*POLYPODIUM VULGARE* L. var. *KAULFUSSII* (D. C. Eat.) Fern. (*P. californicum* Kaulf.) Rock crevices and wooded slopes, west side Mount Hamilton.

*POLYSTICHUM MUNITUM* (Kaulf.) Presl. (*Aspidium munitum* Kaulf.) Wooded slopes, west side of range.

*DRYOPTERIS ARGUTA* (Kaulf.) Walt. (*Aspidium rigidum* var. *argutum* D.C. Eat.) Rocky wooded areas, west side and interior of range.

*WOODWARDIA FIMBRIATA* Sm. (*W. Chamissoi* Brack.; *W. radicans* of authors.) North base Mount Hamilton.

*PITYROGRAMMA TRIANGULARIS* (Kaulf.) Maxon. (*Gymnogramma triangularis* Kaulf.) Occasional across range on wooded slopes, rock ledges and crevices, and talus.

*ADIANTUM JORDANI* Müll. (*A. emarginatum* sensu D. C. Eat., non Bory.) Sheltered rock ledges or moist wooded slopes across range, uncommon.

*CHEILANTHES GRACILLIMA* D. C. Eat. Exposed rock ledges near summit Mount Hamilton.

*CHEILANTHES INTERTEXTA* (Maxon) Maxon. (*C. Covillei* Maxon subsp. *intertexta* Maxon.) Occasional on exposed rock ledges, west side and interior of range.

*PELLAEA MUCRONATA* (D. C. Eat.) D. C. Eat. (*P. ornithopus* Hook.) Occasional across range on rocky slopes and ledges.

*PELLAEA ANDROMEDIFOLIA* (Kaulf.) Fee. Occasional across range on rocky slopes.

## MARSILEACEAE

*MARSILEA VESTITA* Hook. and Grev. Still water, ponds or streams.

## EQUISETACEAE

*EQUISETUM LAEVIGATUM* A. Br. Margins of Santa Isabella Creek.

*EQUISETUM ARVENSIS* L. North base Mount Hamilton; bog.

## SELAGINELLACEAE

*SELAGINELLA BIGELOVII* Underw. Occasional across range on exposed rock crevices and slopes.

## ISOETACEAE

*ISOETES HOWELLII* Engelm. Mount Day Ridge; pond.

## PINACEAE

*PINUS PONDEROSA* Dougl. Grove of ten or twelve trees growing among *P. Coulteri*, east slope Mount Hamilton near summit, *H. K. Sharsmith* 524 (UC). Only two small and isolated groves of *Pinus ponderosa* are known on the mountain, the one cited and another a short distance below on the same slope. Greene (*Erythea* 1: 97. 1893) states, "Fine groves of it [*P. ponderosa*] are seen near the summits of high ridges not far away." Apparently Greene mistook *P. Coulteri* for this species, for he does not list *P. Coulteri*, although it occurs on the summit ridges of Copernicus Peak, a portion of the

Mount Hamilton summit. *Pinus Coulteri* is the abundant pine at altitudes which might support either species.

*PINUS COULTERI* Don. Common on summit ridges of west crest of range: Santa Isabella Peak, Mount Hamilton, Packard Ridge, Valpé Ridge, Mount Day Ridge, Mount Lewis, at altitudes of 3000 to 4000 feet, growing most abundantly or exclusively on the eastern slopes of these ridges. This species, mainly of southern California, reaches its northernmost extension in the Mount Hamilton Range except for two colonies in the vicinity of Mount Diablo.

*PINUS SABINIANA* Dougl. Across range on exposed slopes, ridge tops, gravelly flats, or flood beds of intermittent streams. *Pinus Sabiniana* mingles with *P. Coulteri* at the lower levels of the latter species, or the two sometimes occupy the higher ridge tops together. *Pinus Sabiniana* is most abundant, however, in the interior of the range, where it occupies extensive areas of rolling savannah in association with *Quercus Douglasii*, and it occasionally occurs in the chaparral.

## CUPRESSACEAE

*JUNIPERUS CALIFORNICA* Carr. (*Sabina californica* Antone.) Canyon slopes and gravelly flood beds, across range, mostly in interior and on east side.

*LIBOCEDRUS DECURRENS* Torr. Occurs as a planted tree near summit of Copernicus Peak, but is not known to occur naturally within the Mount Hamilton Range. Information relative to the planting of this species was obtained from Dr. W. H. Wright, Director of the Lick Observatory.

*CUPRESSUS SARGENTII* Jepson var. *DUTTONI* Jepson, type from Cedar Mountain, Jepson 7741; known only from the large colony which occurs on summit of Cedar Mountain.

*CUPRESSUS SARGENTII* Jepson occurs as a planted tree on Copernicus Peak adjacent to *Libocedrus decurrens* and again near an abandoned homestead about one mile by road down the east side of Copernicus Peak.

## TAXACEAE

*TORREYA CALIFORNICA* Torr. Mount Sizer, Hendrix 739 (VTM). Known hitherto in the South Coast Ranges only in the Santa Cruz Mountains; typically an outer Coast Range species of moist, shaded localities.

## NAJADACEAE

*ZANNICHELLIA PALUSTRIS* L. Pool, Santa Isabella Valley.

## JUNCAGINACEAE

*LILAEA SUBULATA* Humb. and Bonpl. Drying vernal pools or margins of slowly moving streams.

## ALISMACEAE

*ALISMA PLANTAGO* L. Santa Isabella Creek.

## GRAMINEAE

*BROMUS RUBENS* L. Common across range on dry, open hills.

\**BROMUS RIGIDUS* Roth. Occasional on dry, open hills, west side of range.

\**BROMUS MOLLIS* L. (*B. hordaceus* L.) Common across range, on dry, open hills.

\**BROMUS ARENARIUS* Labill. Common across range on dry, open hills.

*BROMUS BREVIARISTATUS* Buckl. (*B. subvelutinus* Shear.) Dry slope, west side of Mount Hamilton.

*BROMUS CARINATUS* Hook. and Arn. Open hills, vicinity Smith Creek.

*BROMUS ANOMALUS* Rupr. (*B. Porteri* (Coul.) Nash.) West side Mount Hamilton.

*PUCCINELLIA SIMPLEX* Scribn. Alkaline seepage, Corral Hollow.

*FESTUCA OCTOFLORA* Walt. Occasional in rocky soil.

- FESTUCA PACIFICA Piper. Common across range on open hills.  
 FESTUCA CONFUSA Piper. Open, dry hills, interior and east side of range.  
 FESTUCA GRAYI (Abrams) Piper. Occasional across range on open, dry hills.  
 FESTUCA REFLEXA Buckl. Common across range on open, dry hills.  
 FESTUCA EASTWOODAE Piper. Occasional across range on openly wooded hills.  
 FESTUCA MEGALURA Nutt. Occasional across range on open, dry hills.  
 \*FESTUCA DERTONENSIS (All.) Aschers. and Graebn. Occasional across range on dry hills or wooded slopes.  
 FESTUCA OCCIDENTALIS Hook. and Arn. Copernicus Peak.  
 FESTUCA ELMERI Scribn. and Merr. Wooded slopes, Mount Hamilton.  
 \*POA ANNUA L. Occasional across range.  
 POA HOWELLII Vasey and Scribn. Wooded slopes, Mount Hamilton.  
 \*POA PRATENSIS L. West side Mount Hamilton.  
 POA SCABRELLA (Thurb.) Benth. Common across range on dry, open hills or openly wooded slopes.  
 POA SECUNDA Presl. (*P. Sandbergii* Vasey.) West side Mount Hamilton.  
 DISTICHLIS STRICTA (Torr.) Rydb. (*D. spicata* var. *stricta* Scribn.) Alkaline areas, east margin of range.  
 PHRAGMITES COMMUNIS Trin. Headwaters Arroyo del Puerto.  
 \*LAMARCKIA AUREA (L.) Moench. East of Coyote, *Hendrix 769* (VTM); open hillslope, Oak Ridge, *H. K. Sharsmith 3349* (UC). North of southern California this is a comparatively rare species.  
 MELICA CALIFORNICA Scribn. (*M. bulbosa* of authors, non Geyer.) Common across range on rocky or openly wooded slopes.  
 MELICA TORREYANA Scribn. Occasional across range on rocky or wooded slopes.  
 MELICA IMPERFECTA Trin. var. *FLEXUOSA* Boland. Open slopes, west side of range.  
 AGROPYRON SUBSPICATUM (Link) Hitchc. West side Mount Hamilton.  
 SCRIBNERIA BOLANDERI (Thurb.) Hack. Rocky soil of chaparral slopes, interior of range. Santa Isabella Valley, *H. K. Sharsmith 1856* (UC). This species has been found only in widely separated localities in the South Coast Ranges (Contra Costa County, Mount Hamilton Range, San Luis Obispo County), although it is fairly frequent in the North Coast Ranges and northward to Washington, and it also occurs in the Sierra Nevada. In Mount Hamilton Range it appears to be exclusively a chaparral inhabitant. It is quite common in the vicinity of Arroyo Bayo and Santa Isabella Valley, although an inconspicuous plant.  
 ELYMUS TRITICOIDES Buckl. Moist soil, Santa Isabella Valley.  
 ELYMUS CONDENSATUS Presl. Open hills, west side Mount Hamilton.  
 ELYMUS GLAUCUS Buckl. Stream margins or flood beds, interior of range.  
 ELYMUS GLAUCUS var. *JEPSONI* Davy. Tule Lake.  
 SITANION HANSENI (Scribn.) J. G. Smith. Wooded slopes, east side Mt. Hamilton.  
 SITANION JUBATUM J. G. Smith. Open or wooded hills or canyon slopes across range.  
 SITANION HYSTRIX (Nutt.) J. G. Smith. Corral Hollow.  
 \*HORDEUM MURINUM L. Occasional across range on open hills or exposed flats.  
 \*HORDEUM GUSSONEANUM Parl. West side Mount Hamilton.  
 HORDEUM JUBATUM L. West side Mount Hamilton.  
 HORDEUM NODOSUM L. Occasional across range on moist flats near streams.  
 \*LOLIUM MULTIFLORUM Lam. Spring, north side Mount Hamilton.  
 KOELERIA CRISTATA (Lam.) Pers. Occasional on west side and in interior of range. on dry, rocky, or openly wooded slopes.  
 \*AVENA FATUA L. Common near western base of Mount Hamilton adjacent to cultivated land, uncommon in interior of range.  
 \*AVENA BARBATA Brct. Common across range on open or wooded slopes or flats.  
 DESCHAMPSIA DANTHONIOIDES (Trin.) Munro. (*Aira danthonioides* Trin.) Occasional on eastern side of Mount Hamilton and in interior of range near streams.  
 DESCHAMPSIA ELONGATA (Hook.) Munro. West side Mount Hamilton.  
 \*AGROSTIS VERTICILLATA Vill. Stream edge, northeast base Mount Hamilton.  
 ALOPECURUS HOWELLII Vasey. (*A. saccatus* of authors, non Vasey.) Sag pond, Arroyo Mocho.

\**POLYPOGON LUTOSUS* (Poir.) Hitchc. Occasional at stream margins, west side and interior of range.

\**POLYPOGON MONSPELIENSIS* (L.) Desf. Moist areas, north side Mount Hamilton.

\**CASTRIDIUM VENTRICOSUM* (Gouan) Schinz and Thell. Occasional on west side and interior of range, open ground.

*STIPA PULCHRA* Hitchc. Occasional across range on openly wooded slopes.

*STIPA LEPIDA* Hitchc. Oso Creek.

*PANICUM CAPILLARE* L. var. *occidentale* Rydb. (*P. barbipulvinatum* Nash.) Moist areas, interior and east side of range.

## CYPERACEAE

*ELEOCHARIS MAMILLATA* Lindb. (*E. palustris* (L.) Roem. and Schult. in part.) Occasional in interior of range at creek margins.

*ELEOCHARIS ACICULARIS* (L.) Roem. and Schult. Occasional in moist places, west side and interior of range.

*CAREX PRAEGRACILIS* W. Boott. Moist places, interior and east side of range.

*CAREX DENSE* Bailey. Moist places, west side and interior of range.

*CAREX SERRATODENS* W. Boott. (*C. bifida* Boott. non Roth.) Occasional across range at creek margins or springs.

*CAREX NUDATA* W. Boott. Occasional across range at margins of streams.

## LEMNACEAE

*LEMNA MINOR* L. Murietta Springs, Copernicus Peak.

## JUNCACEAE

*JUNCUS SPHAEROCARPUS* Nees. Stream bed, east slope Mount Hamilton.

*JUNCUS BALTICUS* Willd. (var.?) Colorado Creek, Red Mountains, C. W. and H. K. Sharsmith 3175 (UC). Immature; possibly var. *montanus* Engelm.

*JUNCUS PATENS* Meyer. Seepage areas, north side Mount Hamilton.

*JUNCUS EFFUSUS* L. var. *PACIFICUS* Fern. and Wieg. (*J. effusus* L. of authors.) Seepage areas, Mount Hamilton.

*JUNCUS BUFONIUS* L. Moist areas, interior of the range. The variety *congestus* Wahlb. is not recognized here, although the writer does not feel justified in passing judgment on its validity.

*JUNCUS OCCIDENTALIS* (Coville) Wiegand. (*J. tenuis* Willd. var. *congestus* Engelm.) Moist areas, west side and interior of the range.

*JUNCUS XIPHIODES* Meyer. Moist places, west side of range.

*JUNCUS OXYMERIS* Engelm. Moist places, east side and base of Mount Hamilton.

*JUNCUS ENSIFOLIUS* Wikstr. Boggy area, north side Mount Hamilton.

*LUZULA MULTIFLORA* (Ehrh.) Lej. Wooded areas, west side of range.

## LILIACEAE

*ZYGADENUS VENENOSUS* Wats. Stream margins, east side of range.

*ZYGADENUS FREMONTII* (Torr.) Torr. Occasional in chaparral across range.

*CHLOROGALUM POMERIDIANUM* (DC.) Kunth. (*Laotioë pomeridiana* Raf.) Occasional in chaparral, interior of range.

*ALLIUM UNIFOLIUM* Kell. Stream margins across range; rare. One or two corms arise laterally from short rhizomes which bear the roots.

*ALLIUM FIMBRIATUM* Wats. Abundant on loose serpentine talus near head of Arroyo del Puerto, Red Mountains: H. K. Sharsmith 1676, 3143, 3573 (UC); Elmer 4633 (S). Typically of the desert and mountainous areas of southern California, extending north in the southern Sierra Nevada foothills, and in the inner South Coast Ranges to the Mount Hamilton Range, reappearing in serpentine areas of the North Coast Ranges in Napa and Lake counties.

*ALLIUM PARRYI* Wats. Abundant on loose serpentine talus near head of Arroyo del Puerto, Red Mountains: H. K. Sharsmith 1821, 3117 (UC), Mason in 1935 (UC). General distribution as for the preceding species; found abundantly in the same area in the Mount Hamilton Range, its northern outpost.

*ALLIUM AMPLECTENS* Torr. Dry stream beds, interior of range.

*ALLIUM SERRATUM* Wats. Hills and canyon slopes of Red Mountains and east side of range, especially in serpentine rock.

*ALLIUM PENINSULARE* Lemmon var. *CRISPUM* (Greene) Jepson. (*A. crispum* Greene.) Talus; Red Mountains, Mount Oso.

*ALLIUM BOLANDERI* Wats. Wooded slope, east side Mount Hamilton, *H. K. Sharsmith* 1171, 1224 (UC); summit Mount Day, *H. K. Sharsmith* 3360 (UC). *Allium Bolanderi* was reported from Mount Hamilton by Greene (*Erythea* 1: 96, 1893). The collections cited above represent the first recollections of the species from Mount Hamilton and confirm Greene's record. Of *A. Bolanderi*, Greene says, "Species not before heard of as from any point south of Humboldt County. We have little more than the oblique corm like bulbs and lateral scapes to judge from; but these in this species are very characteristic." The outer coats of the corms have serrate reticulations, while the more delicate inner coats have obscure, undulate reticulations. One to several of these coated corms may be grouped at the base of the slender scape which arises laterally from the corms. This lateral attachment of scape to corm is, as indicated by Greene, highly distinctive, and it serves to delineate *A. Bolanderi* from other species of superficial resemblance. This diagnostic feature is not brought out in the more recent treatments of California species of *Allium*. *Allium Bolanderi* appears to be restricted to the North Coast Ranges and Siskiyou Mountains from Siskiyou County and southern Oregon to Lake County, and to the western summit peaks of the Mount Hamilton Range in the South Coast Ranges.

*ALLIUM LACUNOSUM* Wats. Dry stream beds, infrequent across range.

*ALLIUM FALCIFOLIUM* Hook. and Arn. (*A. falcifolium* var. *Breweri* Jones; *A. Breweri* Wats.) Exposed talus, west side and interior of range. *Allium falcifolium* and *A. Breweri* appear to be identical, but genetic studies are necessary before the question can be adequately decided. Uniting *A. Breweri* with *A. falcifolium*, the older binomial, amplifies the range of the latter species from the Siskiyou Mountains and North Coast Ranges to include as well Mount Diablo, the Mount Hamilton Range, and easterly summit areas of the Santa Cruz Mountains in the South Coast Ranges.

*MULLA SEROTINA* Greene. Monument Peak, *Wilson* 569 (VTM). The known northern station; a species typically of cismontane southern California and adjacent desert areas; infrequent in inner South Coast Ranges.

*BRODIAEA LAXA* (Benth.) Wats. (*Tritelia laxa* Benth.) Occasional across range on wooded slopes or in grassland adjacent to streams.

*BRODIAEA PEDUNCULARIS* (Lindl.) Wats. (*Tritelia peduncularis* Lindl.) Stream margins, Red Mountains. Colorado Creek, *H. K. Sharsmith* 3177 (UC); San Antonio Valley, *Mason* in 1935 (UC); Arroyo del Puerto, *Elmer* 4348 (S, CA). Not otherwise known from South Coast Ranges, but occurring in moist places in North Coast Ranges from Marin County to Humboldt County.

*BRODIAEA HYACINTHINA* (Lindl.) Baker. Moist soil, Red Mountains.

*BRODIAEA CORONARIA* (Salisb.) Jepson. (*Hookera coronaria* Salisb.; *Brodiaea grandiflora* Smith.) Occasional grassy slopes across range, less common than *B. laxa*.

*BRODIAEA CAPITATA* Benth. (*Dichelostemma capitatum* Wood.) A common species across range on grassy hillsides.

*BRODIAEA PULCHELLA* Greene. (*B. congesta* Smith; *D. pulchellum* Heller.) West side Mount Hamilton.

*CALOCHORTUS LUTEUS* Dougl. Common across range on exposed hillsides.

*CALOCHORTUS VENUSTUS* Dougl. Frequent across range on dry, exposed slopes.

*CALOCHORTUS INVENUSTUS* Greene. (*C. Nuttallii* of authors, non Torr.; *C. Nuttallii* var. *australis* Munz.) Rocky outcrop above Colorado Creek, Red Mountains, *H. K. Sharsmith* 3804 (UC). A common species in southern California, and only rarely found in the South Coast Ranges. The Mount Hamilton Range represents its known northern outpost.

*CALOCHORTUS ALBUS* (Benth.) Dougl. Occasional on wooded slopes, west side and interior of range.

*CALOCHORTUS CLAVATUS* Wats. Arroyo del Puerto, *Hoover* 3415 (UC). A species found in southern California and frequent to San Luis Obispo County, but occurring only occasionally in South Coast Ranges north of this; not hitherto collected from the Mount Hamilton Range.

*CALOCHORTUS UMBELLATUS* Wood. On steep canyon slopes beneath chaparral, west side of range. Mainly restricted to North Coast Ranges, the Mount Hamilton Range being its known southern limit.

FRITILLARIA AGRESTIS Greene. (*F. succulenta* Elmer.) Tesla hills above Corral Hollow.

FRITILLARIA LANCEOLATA Pursh. (*F. lanceolata* var. *floribunda* Benth.) Occasional across range on wooded slopes.

FRITILLARIA FOLCATA (Jepson) Beetle, Madroño 7:148. 1944. (*F. atropurpurea* var. *folcata* Jepson.) A species restricted to serpentine talus of inner South Coast Ranges. Known only from the type ("San Benito Co., San Benito Peak," Jepson 2715), and from the Red Mountains of Mount Hamilton Range: Adobe Creek H. K. Sharsmith 1671 (UC), flower and 3579 (UC), fruit; Colorado Creek, Beetle 17 (UC), Carter 1047 (UC).

DISPORUM HOOKERI (Torr.) Britt. Infrequent on wooded slopes, Mount Hamilton. In the South Coast Ranges typically occurring only near the coast. The colony at north base of Mount Hamilton (H. K. Sharsmith 1209, UC) appeared to be persisting vegetatively; in 1934 only abortive flowers were found, and in 1935 none were found.

SMILACINA SESSILIFOLIA (Baker) Nutt. (*Vagnera sessilifolia* Greene.) Shady areas, west side of range; infrequent. In the South Coast Ranges a typically outer Coast Range species.

SMILACINA AMPLEXICAULIS Nutt. (*Vagnera amplexicaulis* Greene.) Dense shade, west side of range; infrequent. Mainly limited to outer Coast Ranges.

TRILLIUM SESSILE L. var. GIGANTEUM Hook. and Arn. (*T. chloropetalum* Howell.) Wooded slopes, west side of range; infrequent. In central California mainly limited to outer Coast Ranges.

#### IRIDACEAE

IRIS LONGIPETALA Herbert. Boggy area, west side Mount Hamilton.

IRIS MACROSPHON Torr. Wooded areas, west side of range.

SISYRINCHIUM BELLUM Wats. Occasional on wooded hillslopes across range.

#### ORCHIDACEAE

HABENARIA UNALASCHENSIS (Spreng.) Wats. (*Piperia unalaschensis* Rydb.) Wooded slope, west side Mount Hamilton; infrequent.

HABENARIA MICHAELI Greene. Rocky ridge, Arroyo del Puerto.

EPIPACTIS GIGANTEA Dougl. (*Serapias gigantea* A. A. Eaton.) North base Mount Hamilton; infrequent.

#### SALICACEAE

POPULUS FREMONTII Wats. Occasional to abundant, stream beds of interior and north and east sides of range.

POPULUS TRICHOCARPA Torr. and Gray. Madrone Springs, Hendrix 722 (VTM).

SALIX LAEVIGATA Bebb. Along streams, interior and east side of range.

SALIX LAEVIGATA Bebb. var. ARAQUIPA (Jepson) Ball. Arroyo Mocho.

SALIX HINDSIANA Benth. Burnt Hills, stream margins.

SALIX MELANOPSIS Nutt. Santa Isabella Creek, east base Mount Hamilton.

SALIX LASIOLEPIS Benth. Stream margins, interior of range.

SALIX BREWERI Bebb. Abundant along streams in isolated localities, Red Mountains.

A distinctive species restricted to inner Coast Ranges from San Luis Obispo to Colusa counties; in the Mount Hamilton Range occurring only in areas of serpentine rock.

#### BETULACEAE

ALNUS RHOMBIFOLIA Nutt. Occasional to abundant along streams of west side of range. There is a single large tree at Aquarius Springs; Greene (*Erythea* 1: 95. 1893) lists this as *Alnus rubra* Bong., apparently an inadvertence.

#### FAGACEAE

QUERCUS LOBATA Nee. Common across range on rolling hills or valley flats.

QUERCUS GARRYANA Dougl. Near Old Gilroy, Hendrix 728 (VTM); Mount Hamilton, Eastwood 12432 (CA). Not otherwise known from Mount Hamilton Range, although more frequent in Santa Cruz Mountains. Hendrix' specimen was taken from a sizeable grove of trees which were very distinct in appearance from *Q. morehus* and other oaks of this area.



*QUERCUS DOUGLASHII* Hook. and Arn. Common across range on rolling hills below 3500 feet, usually associated with *Pinus Sabiniana*.

*QUERCUS DUMOSA* Nutt. Locally abundant across range as an occasional chaparral element.

*QUERCUS DURATA* Jepson. Occasional chaparral element across range, apparently confined to areas of serpentine rock, common in Red Mountains.

*QUERCUS CHRYSOLEPIS* Liebm. West side of range at altitudes above 2250 feet, most abundant on north slopes near summit ridges; also on higher peaks of interior of range; often associated with *Q. Wislizenii*.

*QUERCUS AGRIFOLIA* Nee. Occasional on Mount Hamilton mainly on west side.

*QUERCUS WISLIZENII* DC. Occasional across range as a chaparral constituent; abundant on Mount Hamilton and west side of range as an associate of *Q. chrysolepis* on north facing slopes.

*QUERCUS KELLOGGII* Newb. West side and interior of range above 2000 feet.

*QUERCUS MOREHUS* Kell. Near Lost Lake, *Hendrix 721* (VTM). A hybrid of *Q. Wislizenii* x *Q. Kelloggii*, to be expected in regions where both parent species occur.

#### JUGLANDACEAE

*JUGLANS HINDSII* (Jepson) Jepson. (*J. californica* Wats. var. *Hindsii* Jepson.) North end Adobe Valley, *H. K. Sharsmith 3567a* (UC). A central Californian species occurring as a native only in a few isolated, highly localized areas; not reported hitherto from the Mount Hamilton Range. The Adobe Valley locality is far removed from any habitation, and the single tree appears not to have been planted by white man.

#### URTICACEAE

*URTICA GRACILIS* Ait. var. *HOLOSERICEA* (Nutt.) Jepson. (*U. holosericea* Nutt.) Occasional near springs, west side and interior.

\**URTICA URENS* L. Stream bed, Arroyo del Puerto.

#### LORANTHACEAE

*PHORADENDRON FLAVESCENS* Nutt. var. *MACROPHYLLUM* Engelm. (*P. longispicum* Trel.) Common parasite on *Populus Fremontii*, east and north sides of range.

*PHORADENDRON VILLOSUM* Nutt. (*P. flavescens* var. *villosum* Engelm.) Parasite on *Quercus*, west side Mount Hamilton.

*ARCEUTHOBium CAMPYLOPODUM* Engelm. (*Razoumofskyia campylopoda* Kuntze.) Parasite on *Pinus Sabiniana*.

#### POLYGONACEAE

*POLYGONUM PARRYI* Greene. Rocky, dry sag pond in chaparral near Santa Isabella Valley, *H. K. Sharsmith 3311* (UC). The only known record of this species in the South Coast Ranges. It occurs in the higher parts of the North Coast Ranges northward to Washington, and is also reported from the central Sierra Nevada and the Cuyamaca Mountains (San Diego County).

\**RUMEX CRISPUS* L. Occasional weed in valley flats.

\**RUMEX CONGLOMERATUS* Nutt. Occasional weed in moist, valley flats.

\**RUMEX ACETOSELLA* L. Grassy slope, Mount Hamilton.

*RUMEX SALICIFOLIUS* Weinm. Occasional in moist flats across range.

*PTEROSTEGIA DRYMARIODES* Fisch. and Mey. Moist wooded slope, Arroyo del Puerto.

*CHORIZANTHE MEMBRANACEA* Benth. (*Eriogonella membranacea* Goodm.) Common vernal species on dry, open slopes across range.

*CHORIZANTHE UNIAURISTATA* Torr. and Gray. Red Mountains.

*CHORIZANTHE CLEVELANDII* Parry. Occasional in chaparral or dry, sandy flood beds of streams. Santa Isabella Creek, *H. K. Sharsmith 1132* (UC); between Arroyo Bayo and San Antonio Valley, *H. K. Sharsmith 3298* (UC). A species of intermittent distribution, occurring in the inner Coast Ranges from Mendocino County to Tulare County, and apparently not found between Lake County and the Mount Hamilton Range. The above are the first collections made between the San Carlos Range and Lake County. *Chorizanthe Clevelandii* is easily mistaken for *C. uniauristata*, with which it is closely

allied, but from which it differs in having uncinat, nearly equal involuclral spines, and a perianth of different size and shape.

*CHORIZANTHE POLYGONOIDES* Torr. and Gray. (*Acanthogonum polygonoides* Goodm.) Talus, Arroyo del Puerto.

*CHORIZANTHE PERFOLIATA* Gray. (*Mucronea perfoliata* Heller.) Arroyo del Puerto, H. K. Sharsmith 1755 (UC); Puerto Canyon, Brewer 1261 (UC). The above citations represent the known northern limit of this typically desert species.

*ERIOGONUM ANGULOSUM* Benth. Grassy hillslopes and steep talus, east side of range. A southern Californian species which reaches its northern limit in eastern Contra Costa County just north of the Mount Hamilton Range.

*ERIOGONUM INERME* (Wats.) Jepson. (*E. vagans* Wats.) Occasional in rocky soil of chaparral or in dry, sandy flood beds of streams. Santa Isabella Peak, H. K. Sharsmith 3382 (UC); Red Mountains, H. K. Sharsmith 3792 (UC). An uncommon species occurring from southern California northward in the inner South Coast Ranges to Mount Hamilton Range; not previously reported north of San Carlos Range (San Benito County).

*ERIOGONUM VIRGATUM* Benth. (*E. vimineum* subsp. *virgatum* Stokes.) A common autumnal species of open hills and valley flats; across range, but most abundant in interior.

*ERIOGONUM VIMINEUM* Dougl. A common late spring species across range, but most abundant in interior on open, rocky slopes, often occurring in chaparral.

*ERIOGONUM COVILLEANUM* Eastw. Proc. Calif. Acad. Sci. ser. 4, 20:138. 1931; type, "road from the summit of Mount Hamilton to Livermore" (Arroyo Bayo), Eastwood, April 26, 1927 (CA1). Shale and serpentine talus, interior and east side of range. Arroyo Bayo, H. K. Sharsmith 3061 (UC), topotype; Colorado Creek, H. K. Sharsmith 3162 (UC); Adobe Creek, H. K. Sharsmith 3576 (UC); Arroyo del Puerto, H. K. Sharsmith 3122a (UC). A species which is restricted to the inner South Coast Ranges from Santa Clara County to Monterey County. It is related to the *E. vimineum* complex, but in addition to its distinctive morphological features it blooms in April and May whereas *E. vimineum* and allies bloom in August and September.

*ERIOGONUM SAXATILE* Wats. Rock crevices, northeast ridge of Copernicus Peak near summit of Mount Hamilton, H. K. Sharsmith 1299 (UC), Carter 648 (UC). *Eriogonum saxatile* was collected long ago near the summit of Mount Hamilton by E. L. Greene (Erythra 1:84. 1893)—"probably the northern limit of the species." The above citations represent the first recollections of this species at Mount Hamilton, the known northern outpost of the species. Despite Greene's early collections and several more recent collections from the eastern side of the Santa Cruz Mountains and one from the Pinnacles of San Benito County (Howell, Leaflet West. Bot. 2:99. 1938), it has not been commonly realized that this species occurs in the South Coast Ranges.

*ERIOGONUM WRIGHTII* Torr. (*E. trachygynum* Torr.; *E. trachygynum* subsp. *Wrightii* Stokes.) Occasional to abundant across range on rocky ridges.

*ERIOGONUM FASCICULATUM* Benth. var. *FOLIOSUM* (Nutt.) Stokes. Rocky canyon slopes, usually a chaparral element, east side of range. This variety represents the most abundant phase of the species. It is common in cismontane southern California, and occurs northward in the inner South Coast Ranges to Mount Hamilton Range. Corral Hollow is its northern outpost.

*ERIOGONUM NUDUM* Dougl. var. *AURICULATUM* (Benth.) Tracy. Dry, rocky slopes, Mount Hamilton.

*ERIOGONUM NUDUM* Dougl. var.? Occasional on rocky slopes or in chaparral, interior and east side of range. Seeboy Ridge, H. K. Sharsmith 3879 (UC); Adobe Creek, H. K. Sharsmith 3909 (UC); Arroyo del Puerto, Hoover 2629 (UC). These specimens approach the variety *pubiflorum* Benth. of southern California. The involuclres are one to three in a place, and the calyx is deep yellow. In the variety *pubiflorum*, however, the calyx is hairy toward the base, and in the Mount Hamilton Range plants it is glabrous.

*ERIOGONUM UMBELLATUM* Torr. var. *STELLATUM* Jones. (*E. stellatum* Benth.; *E. umbellatum* subsp. *stellatum* Stokes; *E. umbellatum* var. *bahiaeforme* Jepson; *E. trichotomum* Small (Bull. Torr. Bot. Club 25:43. 1898), type from Mount Hamilton, Greene). North slope Mount Hamilton near summit, Stokes 100 (UC); listed by

Greene (*E. stellatum*, *Erythea* 1:83, 1893) as "very common on sunny slopes... near the summit of Mount Hamilton."

## CHENOPODIACEAE

\**CHENOPODIUM ALBUM* L. Occasional in flood beds of streams, west side of range.

*CHENOPODIUM CALIFORNICUM* Wats. Occasional on wooded slopes, west side and interior of range.

*ATRIPLEX SERENANA* Nels. (*A. bracteosa* Wats.) Adobe Creek.

\**SALSOLA KALI* L. var. *TENUIFOLIA* G. F. W. Mey. Lick Observatory, summit Mount Hamilton.

## AMARANTHACEAE

\**AMARANTHUS BLITOIDES* Wats. Flood bed Santa Isabella Creek.

*AMARANTHUS CALIFORNICUS* (Moq.) Wats. Mount Day Ridge.

## AIZOACEAE

\**GLINUS LOTOIDES* L. Abundant in dried mud, edge of sag pond, Mount Day Ridge, Carter 1201 (UC), H. K. Sharsmith 3837 (UC). An adventive species reported in California at several isolated stations. Carter 1201 is the first collection from Mount Hamilton Range.

## PORTULACACEAE

*CALYPTRIDIMUM MONANDRUM* Nutt. Abundant in chaparral, divide between Arroyo Bayo and San Antonio Valley, H. K. Sharsmith 3077 (UC); Corral Hollow, Hoover 3044 (UC). Typically a species of southern California, Colorado and Mohave deserts, and western Arizona; occurring infrequently in the inner South Coast Ranges as far north as Mount Hamilton Range, known there only from these two collections.

*CALYPTRIDIMUM PARRYI* Gray. Chaparral, northeast side Mount Santa Isabella, H. K. Sharsmith 3381 (UC). A species of the mountainous areas of southern California, not heretofore reported north of Mount Pinos in the Tehachapi Mountains. Determined by R. S. Ferris who reports, "Somewhat aberrant form (slender), but well within the variation of the species."

*CALANDRINIA CILIATA* (Ruiz and Pavon) DC. var. *MENZIESII* (Hook.) Macbr. (*C. caulescens* H. B. K. var. *Menziesii* Gray.) Common vernal annual in moist valley flats across range.

*MONTIA FONTANA* L. Moist areas, interior of range.

*CLAYTONIA PERFOLIATA* Donn. (*Montia perfoliata* Howell; *Limnia perfoliata* How.; *Claytonia nubigena* Greene; *M. perfoliata* var. *nubigena* Jepson; *Limnia nubigena* Heller; *Montia perfoliata* var. *depressa* (Gray) Jepson; *M. perfoliata* var. *parviflora* (Dougl.) Jepson.) Shady wooded slopes or on steep talus in chaparral, across range.

*CLAYTONIA GYPSOPHILOIDES* Fisch. and Mey. (*Montia gypsophiloides* Howell; *Limnia gypsophiloides* Heller; *L. diaboli* Rydb.) Across range, but most abundant on rocky slopes which occur as openings in chaparral or on steep talus. Distinctions between *Limnia gypsophiloides* and *L. diaboli* Rydb., as outlined by Rydberg (North American Flora 21:311, 1932), tenuous at best, do not hold in Mount Hamilton Range material.

*LEWISIA REDIVIVA* Pursh. Rocky ridges or slopes, interior of range, rare.

## CARYOPHYLLACEAE

\**CERASTIUM VISCOSUM* L. Occasional in grasslands, across range.

*CERASTIUM ARVENSE* L. var. *MAXIMUM* Holl. and Britt. (*C. viride* Heller, Muhl. 2:281, 1907. Type from Alum Rock Park, Mount Hamilton Range, Heller 8485.) Alum Rock Park.

\**STELLARIA MEDIA* (L.) Cyr. Uncommon in Mount Hamilton Range except in cultivated area near base of western slope.

*STELLARIA NITENS* Nutt. Occasional across range on grassy, openly wooded slopes.

*SAGINA OCCIDENTALIS* Wats. Santa Isabella Creek.

\**SAGINA APETALA* Ard. var. *BARBATA* Fenzl. Occasional in moist places, interior and east side of range.

*ARENARIA MACROPHYLLA* Hook. (*Moehringia macrophylla* Torr.) Common on wooded slopes near summits of higher peaks on west side of range.

*ARENARIA DOUGLASII* Fenzl. Frequent across range on rocky slopes.

*Arenaria Douglasii* Fenzl. var. *emarginata* var. nov. Petalis obovatis plerumque emarginatis nonnunquam irregulariter dentatis vel nihil nisi obtusis 2-3 mm. longis sepala in fructu aequalibus vel vix superantibus, staminibus aequalibus 2 mm. longis brevioribus quam petalis sepalisque, antheris 0.2-0.3 mm. longis.

Connate bases of leaves not white-scarious, lower leaves up to 6 cm. long, withering early; flowers 3 mm. long, 2.5 mm. wide; sepals 2-2.5 mm. long in flower, 3-3.5 mm. long in fruit, red tipped or sometimes red throughout; petals obovate, usually emarginate, occasionally merely obtuse, 2-3 mm. long, often slightly longer than sepals before anthesis, about equal to fruiting sepals after anthesis; stamens equal, 2 mm. long, shorter than petals and sepals, bidentate gland small, anthers 0.2-0.3 mm. long; styles feathery to base.

Type. West talus of canyon, Adobe Creek, Stanislaus County, Red Mountains, Mount Hamilton Range of South Coast Ranges, California, altitude 1800 feet, April 22, 1936, H. K. Sharsmith 3575 (UC). Other specimens. Adobe Creek, H. K. Sharsmith 1670 (topotype, immature, UC); Adobe Creek, H. K. Sharsmith 3585 (UC), Carter 1158 (UC), Arroyo del Puerto, H. K. Sharsmith 3762 (UC).

The close affinity of *Arenaria Douglasii* and *A. Douglasii* var. *emarginata* is indicated by the general features of the plants, and also by the presence of yellowish bidentate glands on those stamens which are opposite the sepals. The other two annual Californian species of the section *Alsine* (*A. californica* and *A. pusilla*) do not possess these glands.

The most distinctive features of *Arenaria Douglasii* var. *emarginata* lie in the flowers, and particularly in the petals and stamens, although intergradation with the species occurs to some extent. Thus, in the variety the petals may be irregularly toothed or merely obtuse, but the emarginate condition prevails, and the petals do not or scarcely exceed the fruiting sepals; the stamens are 2 mm. long, shorter than petals and sepals, and equal; the anthers are 0.2-0.3 mm. long, and the bidentate gland at the base of the five stamens is relatively small. In the species the petals are always obtuse, and are often twice as long as the fruiting sepals, although occasionally they may be as short as the sepals; the stamens are up to 4 mm. long, often exceeding the sepals and often unequal; the anthers are 0.5-0.7 mm. long; and the bidentate gland is relatively large.

*Arenaria Douglasii* var. *emarginata* (H.K.S. 3956) and *A. Douglasii* (H.K.S. 3957) were grown from seed, and observed simultaneously from germination to maturity. The differences referred to in the preceding paragraph were observable in the cultivated plants.

*Arenaria Douglasii* is found with *A. Douglasii* var. *emarginata* in the Red Mountains of the Mount Hamilton Range, but their colonies do not intermingle. *Arenaria Douglasii* is common on exposed, dry rock outcroppings throughout the range, but so far *A. Douglasii* var. *emarginata* has been found only on the unstable serpentine or shale talus of the Red Mountains.

*ARENARIA CALIFORNICA* (Gray) Brewer. Occasional in interior of range on rocky chaparral slopes or open hillsides. A rare species in the South Coast Ranges.

*ARENARIA PUSILLA* Wats. Frequent in rocky soil of chaparral, interior of range. Sulphur Spring Creek, C. W. and H. K. Sharsmith 3435 (UC); Arroyo Mocho near Colorado Creek, H. K. Sharsmith 3514 (UC); Sugarloaf Mountain, H. K. Sharsmith 3635 (UC); Arroyo Bayo, H. K. Sharsmith 1982a (UC). For many years *A. pusilla* was known in Washington and Oregon, and as far south as Humboldt County in the North Coast Ranges of California. A citation by Munz (Man. S. Calif. Bot. 163, 1935; Laguna Mountains, San Diego, Munz 9672, P!) extends our knowledge of the range of this species to the southern extremity of California. The citations above are the first record of specimens collected between Humboldt County and San Diego County, and they partly eliminate the discontinuity in the known range of the species. *Arenaria pusilla* probably occupies other favorable localities in the Coast Ranges, but its small size prevents easy detection.

The Mount Hamilton Range specimens collected in 1936 (3435, 3514, 3635) are uniformly smaller than available herbarium material of *A. pusilla*, and are also smaller than Watson's type sheet (G!) and Munz' San Diego specimen, but they are similar in all other respects. Their depauperate nature seems to have been conditioned by aridity,

as 1936 was a year of low rainfall in this region. The collection made in 1935 (1982a), a year of average rainfall for the region, shows normal sized plants.

*Arenaria pusilla* belongs to the section *Alsine* Benth. and Hook. Its closest relative is *A. californica* (Gray) Brewer. Both species occur in the Mount Hamilton Range. They are distinguished by features which seem not to intergrade. *Arenaria pusilla* is smaller; the sepals are narrowly lanceolate and acuminate; the petals are shorter than the sepals or wanting; and the stamens are two-thirds the length of the sepals. *Arenaria californica* is larger; the sepals are oblong-ovate and acute; the petals are one-half again the length of the sepals; and the stamens are as long as the sepals.

*SPERGULARIA ATROSPERMA* R. P. Rossbach. Alkaline seepage, Elk Ravine, Corral Hollow, Ferris 9412 (S).

*SPERGULARIA SALIGNA* J. and C. Presl. Corral Hollow.

*LOEFLINGIA SQUARROSA* Nutt. Rocky flood plain, Corral Hollow, Carter 788 (UC). An infrequently collected species.

\**HERNIARIA CINEREA* DC. Grassland, east side of range.

\**SILENE GALLICA* L. Occasional on grassy slopes, west side of range.

#### RANUNCULACEAE

*PAEONIA BROWNII* Dougl. Large colony persisting mainly by vegetative propagation, buds small and abortive, flowers few or none; east side Mount Hamilton, H. K. Sharsmith 3947 (UC). This colony was located by G. L. Stebbins, Jr.; it is discussed in his recent paper on *Paeonia* (Madroño 4:252-260. 1938).

*ISOPYRUM OCCIDENTALE* Hook. and Arn. Occasional on north facing, wooded slopes, west side and interior of range; frequent on east side of Mount Hamilton in moist, loose humus under *Quercus Kelloggii*. *Isopyrum occidentale* is a highly localized and infrequently collected although widely distributed species. Isolated stations occur in Butte, Amador, Mariposa, and Kern counties in the Sierra Nevada; Vaca Mountains, Mount Hamilton Range, Santa Cruz Mountains, and San Carlos Range in the Coast Ranges; Tehachapi Mountains in southern California.

*ISOPYRUM STIPITATUM* Gray. Moist, north facing, wooded slopes, west side and interior of range, usually growing with *I. occidentale*; rare. *Isopyrum stipitatum* is, like *I. occidentale*, a highly localized species, but it is considerably less well known. The reported stations for it occur mainly in Modoc and Siskiyou counties. Comparison of the two species from the Mount Hamilton Range, where they grow together intimately, leaves no doubt as to their specific differentiation. Careful observation shows several definite field characters by which the two species may be distinguished: *I. stipitatum* is about two-thirds the size of *I. occidentale*, and its fascicled roots are truncate, whereas in *I. occidentale* they are long attenuate; the smaller leaves of *I. stipitatum* are pale and glaucous above as well as below, and the ultimate leaf segments are much narrower, more completely dissected, and less fan-shaped than in *I. occidentale*. The foliicles of *I. stipitatum* are on peduncles which are shorter than the leaves and strongly reflexed, so that the fruits lie on or near the surface of the soil; in *I. occidentale* the peduncles are longer than the leaves and strictly erect, bringing the foliicles well above the foliage. It is possible that the apparent rarity of *I. stipitatum* may be due partly to its inconspicuous habit and to the ease with which it could be passed over for small-sized plants of the more obvious *I. occidentale* where the two species grow together.

*AQUILEGIA FORMOSA* Fisch. subsp. *TRUNCATA* (Fisch. and Mey.) Jones. (*A. truncata* Fisch. and Mey.) Wooded slopes, west side and interior of range.

*AQUILEGIA TRACYI* Jepson. Santa Isabella Creek, Mount Hamilton, H. K. Sharsmith 1215 (UC); margin of spring, Red Mountains, H. K. Sharsmith 3895 (UC). It has not been recorded hitherto from the Mount Hamilton Range.

*DELPHINIUM NUDICAULE* Torr. and Gray. Occasional on rocky slopes across range.

*DELPHINIUM PATENS* Benth. (*D. decorum* of authors, non Fisch. and Mey.) Frequent on wooded, north facing slopes, across range.

*DELPHINIUM PATENS* Benth. x *D. NUDICAULE* Torr. and Gray. East side Mount Hamilton, H. K. Sharsmith 3052, flowers, 3224, seeds (UC). On the rocky chaparral

clearing where the specimens were found, *D. nudicaule* and *D. patens* were common in separate colonies. At the contact zone where individuals of the species of one *Delphinium* colony overlapped with individuals of the other colony, several plants were found which could be interpreted only as natural hybrids between *D. patens* and *D. nudicaule*. The rich purple-red corolla color, unfortunately somewhat faded with pressing, is the most outstanding indication of this hybrid ancestry. Except for color, the flower is closer to that of *D. patens*, but the glandular-pubescent follicles are like those of *D. nudicaule* instead of glabrous as in *D. patens*. The large, glabrous, succulent and mostly basal leaves with broad segments, and the woody, fibrous root system closely approach *D. nudicaule*. Such a hybrid involves a cross between two sections of the genus, Section *Phoenicodelphis*, to which belongs *D. nudicaule*, and Section *Delphiniastrum*, to which belongs *D. patens*.

*DELPHINIUM CALIFORNICUM* Torr. and Gray. Dry ravine near San Antonio Creek.

*DELPHINIUM CALIFORNICUM* Torr. and Gray var. *INTERIUS* Eastw. Leaflet. West. Bot. 2:137, 1938, type from Hospital Canyon, Mount Hamilton Range, *Eastwood* and *Howell* 5796 (CA). Interior and east side of range, infrequent in dry ravines. This variety is possibly distinct from *D. californicum*, from which it may be separated by its glabrous or glabrate flowers and persistent leaves. It appears to be limited in distribution to the Mount Hamilton Range and Mount Diablo.

*DELPHINIUM VARIEGATUM* Torr. and Gray. Common late spring species on openly wooded hills and in valleys, interior and east side of range. The typical phase of the species is not found in central California, and the Mount Hamilton Range collections should be referred to a variety or subspecies.

*DELPHINIUM HESPERIUM* (Brew. and Wats.) Gray. Common late spring species in openly wooded hills and valleys, mostly in interior of range.

*DELPHINIUM HESPERIUM* Gray var. *SEDTIOSUM* Jepson. Openly wooded hills, interior and east side of range.

*DELPHINIUM PARRYI* Gray. Occasional, interior of range on openly wooded hills. Common in southern California, but here at the northern margin of its distribution.

*DELPHINIUM PARRYI* Gray x *D. VARIEGATUM* Torr. and Gray? San Antonio Valley, *H. K. Sharsmith* 3096b (UC). A small colony of this apparent hybrid occurred under oaks near *D. variegatum* and *D. Parryi*.

*THALICTRUM POLYCARPUM* (Torr.) Wats. Wooded slopes across range.

*MYOSUROS LEPTURUS* (Gray) Howell. (*M. aristatus* Benth. var. *lepturus* Jepson; *M. apetalus* var. *lepturus* Gray.) Sag pond between Arroyo Bayo and Santa Isabella Valley.

*MYOSUROS MINIMUS* L. Moist depressions or in chaparral, east side and interior of range.

*MYOSUROS MINIMUS* L. var. *FILIFORMIS* Greene. Vernal pool, Arroyo Mocho. Questionably distinct from the species.

*RANUNCULUS CALIFORNICUS* Benth. Common vernal species across range on moist slopes or valley flats.

*RANUNCULUS HEBECARPUS* Hook. and Arn. Occasional on wooded slopes across range.

*RANUNCULUS TRICHOPHYLLUS* Chaix. (*R. aquatilis* L. var. *trichophyllus* Gray; *R. aquatilis* L. var. *capillaceus* DC.) Vernal pools or sluggish streams, interior of range.

*RANUNCULUS TRICHOPHYLLUS* Chaix. var. *HISPIDULUS* (E. Drew) W. Drew. (*R. aquatilis* of authors, non L.) Sag pond, Mount Day Ridge.

*CLEMATIS LASIANTHA* Nutt. Occasional on brush or chaparral slopes, across range.

#### BERBERIDACEAE

*BERBERIS DICTYOTA* Jepson. (*B. californica* Jepson; *Odoestemon dictyota* Abrams; *Berberis aquifolium* var. *dictyota* Jepson.) Brushy slopes, interior of range; infrequent.

*BERBERIS PINNATA* Lag. Smith Creek.

#### LAURACEAE

*UMBELLULARIA CALIFORNICA* Nutt. Frequent on west side of range, wooded or brushy slopes, infrequent in interior of range.



## PAPAVERACEAE

*PLATYSTEMON CALIFORNICUS* Benth. Frequent vernal annual, open slopes or valley flats across range.

*ARGEMONE PLATYCERAS* Link and Otto. (*A. platyceras* var. *hispidus* (Gray) Prain.) Dry stream bed, Arroyo del Puerto.

*PAPAVER HETEROPHYLLUM* (Benth.) Greene. Occasional vernal annual across range on wooded slopes.

*ESCHSCHOLTZIA CALIFORNICA* Cham. (*E. crocea* Benth.) Common vernal annual across range, locally abundant in colonies on grassy hillslopes.

*ESCHSCHOLTZIA CAESPITOSA* var. *HYPECOIDES* (Benth.) Gray. Occasional on grassy slopes, interior and east side of range. Arroyo del Puerto, *H. K. Sharsmith 1740, 1810* (UC), *Hoover 3361* (UC); between Arroyo Bayo and San Antonio Valley, *H. K. Sharsmith 3076* (UC). These collections are dubiously referred to this variety. The white, scale-like hairs and finer pubescence, particularly on *H. K. S. 1740* and *Hoover 3361*, suggest *E. Lemmonii*.

*ESCHSCHOLTZIA CAESPITOSA* var. *RHOMBIPETALA* (Greene) Jepson. Infrequent on grassy slopes or talus, interior and east side of range.

## FUMARIACEAE

*DICENTRA CHRYSANTHA* (Hook. and Arn.) Walp. Abundant in isolated colonies in interior and east side of range; often on burned-over land.

## CRUCIFERAE

*THELYPIDIUM FLAVESCENS* (Hook.) Wats. (*Caulanthus flavescens* Payson; *Streptanthus Dudleyi* Eastw.) Corral Hollow.

*THELYPIDIUM LASIOPHYLLUM* (Hook. and Arn.) Greene. (*Caulanthus lasiophyllus* Payson; *Guillenia lasiophylla* Greene.) Occasional vernal annual across range on grassy slopes.

*STREPTANTHUS COULTERI* (Wats.) Gray var. *LEMMONII* (Wats.) Jepson. (*S. Parryi* Greene; *S. Lemmonii* Jepson; *Caulanthus Lemmonii* Wats.) Occasional along east base of range.

*STREPTANTHUS BREWERI* Gray. Unstable talus, Red Mountains, the type locality. Summit of mountain north of Camp 75 (near head of Arroyo del Puerto), *Brewer 1268* (isotype, UC!); head of Arroyo del Puerto, *C. W. and H. K. Sharsmith 3149* (UC); Colorado Creek canyon, *C. W. and H. K. Sharsmith 3167* (UC); Red Mountain, *Elmer 4345* (UC). A distinctive species restricted to rocky, serpentine slopes mainly of unstable talus, occurring in the Lake County area of inner North Coast Ranges, and in Mount Hamilton Range and San Carlos Range of inner South Coast Ranges.

*STREPTANTHUS GLANDULOSUS* Hook. (*S. Mildredae* Greene, type from Mount Hamilton, *Mildren Holden*; *Euclisia Mildredae* Greene.) Frequent across range on rocky slopes. The Mount Hamilton plants distinguished as *S. Mildredae* by E. L. Greene do not warrant separation from the polymorphic *S. glandulosus*.

*STREPTANTHUS ALBIDUS* Greene. (*S. glandulosus* Hook. var. *albidus* Jepson.) Serpentine outcrop, Metcalfe road, west side Mount Hamilton near base, *H. K. Sharsmith 3956* (UC). A little known species limited to the west base of Mount Hamilton Range and to Mount Diablo; restricted to serpentine. The type was collected in the Mount Hamilton Range four miles south of San Jose above Cincas Creek by Rattan in 1886 (isotype, SI). A subspecies of *S. glandulosus* according to J. L. Morrison (A monograph of the section *Euclisia* Nutt., of *Streptanthus* Nutt. Thesis, U. of Calif., 1941. 103 mss. pp.).

*STREPTANTHUS CALLISTUS* Morrison, *Madroño* 4: 205. 1938. Shale talus, Arroyo Bayo, Mount Hamilton Range, May 5, 1935, *C. W. and H. K. Sharsmith 3074* (type, UC!). A very narrow endemic, found only at the type locality; topotypes collected by Keck and Clausen in 1937 ("very rare"), and by Morrison in 1937 ("mature siliques and seeds") and 1938 ("abundant in the area").

*STREPTANTHUS LILACINUS* Hoover, *Leaflet West. Bot.* 1:226. 1936. Corral Hollow, Mount Hamilton Range, April 7, 1935, *Eastwood and Howell 2111*, type (isotype, CA!); Arroyo del Puerto, *H. K. Sharsmith 1592* (UC).

*DESCURAINIA PINNATA* (Walt.) Britt. subsp. *MENZIESII* (DC.) Detling. (*Sisymbrium pinnatum* Greene.) Occasional on grassy slopes of interior and east side of range.

\**BRASSICA CAMPESTRIS* L. Abundant in agricultural lands at west base Mount Hamilton, but uncommon elsewhere across range.

\**BRASSICA ARVENSIS* (L.) Rabenh. Uncommon.

\**BRASSICA INCANA* (L.) Meigen. (*B. adpressa* Boiss.) Uncommon.

*BARBAREA ORTHOCERAS* Ledeb. var. *DOLICHOCARPA* Fern. (*B. vulgaris* of authors in part, non R. Br.) Occasional in moist areas, west side and interior of range.

*RADICULA NASTURTIUM-AQUATICUM* (L.) Brit. and Rendle. (*Rorippa Nasturtium-aquaticum* Schinz. and Thell.) North side Mount Hamilton; bog.

*RADICULA CURVISILIQUA* (Hook.) Greene. (*Rorippa curvisiliqua* Bessey.) Occasional in moist places, west side and interior of range.

*CARDAMINE OLIGOSPERMA* Nutt. Wooded slopes, west base of range.

*DENTARIA INTEGRIFOLIA* Nutt. var. *CALIFORNICA* (Nutt.) Jepson. (*Cardamine californica* Greene.) Common on wooded, north-facing slopes across range.

*ARABIS GLABRA* (L.) Bernh. Grassy slope, Colorado Creek.

*ARABIS BREWERI* Wats. var. *TYPICA* Rollins. Rocky outcrops, 2000 to 4000 feet, west side and interior of range. In the present survey, *A. Breweri* was found to be rare near the summit of Mount Hamilton, but references to this species by Greene (*Erythea* 1: 87. 1893) and Heller (*Muhl.* 2:285. 1907) imply that it was once more abundant there.

*ERYSIMUM CAPITATUM* Greene. (*E. asperum* of authors.) Occasional on dry, rocky slopes across range.

*TROPIDIOCARPUM GRACILE* Hook. Occasional on grassy slopes across the range.

*TROPIDIOCARPUM CAPPARIDEUM* Greene. Mountain House (Altamont Pass), *Rose* 330/9 (UC); between Altamont Pass and Patterson Pass, *Mason* 68/8 (UC). Also at San Joaquin County entrance to Corral Hollow according to H. L. Mason (oral communication). An endemic restricted to the area lying between Byron Hot Springs and the northeastern borders of the Mount Hamilton Range.

*LEPIDIUM NITIDUM* Nutt. Common vernal annual across range on grassy slopes.

*LEPIDIUM LATIPES* Hook. Summit of Red Mountains.

*PLATYSPERMUM SCAPIGERUM* Hook. Headwaters of Alameda Creek north of Packard Ridge, *Mason* 7209 (UC), *Ferris* and *Bacigalupi* 8285 (S), the only records for this species from the Coast Ranges. It occurs from the northern Sierra Nevada north to Washington and Idaho, reaching its highest developments in the northwest.

\**CAPSELLA BURSA-PASTORIS* (L.) Medic. (*Bursa pastoris* Dorsten.) Established across range at isolated localities.

*CAPSELLA PROCUMBENS* (L.) Fries. (*Hutchinsia procumbens* Desv.) Grassy areas, east side of range.

*DRABA UNILATERALIS* Jones. (*Athysanus unilateralis* Jepson.) Occasional, east side of range.

*ATHYSANUS PUSILLUS* (Hook.) Greene. Common vernal annual on grassy slopes across range.

*THYSANOCARPUS CURVIPES* Hook. Common vernal annual across range on grassy, openly wooded slopes.

*THYSANOCARPUS LACINIATUS* Nutt. var. *CRENATUS* (Nutt.) Brew. Habitat and occurrence of preceding.

*THYSANOCARPUS RADIANUS* Benth. Habitat and occurrence of the two species preceding, but much less frequent.

*TILLAEA AQUATICA* L. var. *DRUMMONDII* (Torr. and Gray) Jepson. (*T. Drummondii* Torr. and Gray; *Tillaeastrum Drummondii* Britton.) Occasional in moist areas, interior of range.

*TILLAEA ERECTA* Hook. and Arn. (*T. minima* Miers.) Occasional on grassy or mossy slopes across range.

*SEDELLA PENTANDRA* H. K. Sharsmith, *Madroño* 3:240. 1936. Occasional on shale, slate, or sandstone areas which dry out early; canyon slopes, edges of open chaparral, or margins of small, intermittent streams, interior and east side of range. Type from Arroyo del Puerto, C. W. and H. K. Sharsmith 1831 (UC!). Since its discovery in

the Mount Hamilton Range, this species has been reported in the South Coast Ranges from the Pinnacles of San Benito County (Howell, Leaflet. West. Bot. 2:99, 1938—Howell 12939, CA, UC), and from the San Carlos Range (Mason, oral communication, 1940). It has been collected recently in the inner North Coast Ranges in Lake County as well (Sharsmith, Madroño 5:194, 1940).

*SEDUM RADIATUM* Wats. Occasional among rocks, Mount Hamilton.

*SEDUM SPATHULIFOLIUM* Hook. Cliffs, north base Mount Hamilton.

*ECHEVERIA LAXA* Lindl. var. *PANICULATA* Jepson; type from Morrison Canyon near Niles (extreme north end of Mount Hamilton Range), Jepson 13419. (*Dudleya paniculata* Brit. and Rose; *Cotyledon laxa* var. *paniculata* Jepson.) Occasional on rock cliffs across range. This variety is of dubious distinction. The small stature of the plants and consequent "paniculate" inflorescence may be merely a matter of the growth stage represented. If the plants were to increase in size, they might show a "racemose" type of inflorescence like that attributed to *E. laxa* var. *Setchellii* (see below).

*ECHEVERIA LAXA* Lindl. var. *SETCHELLII* Jepson, type from Coyote Creek, Setchell and Jepson in 1896 (foothills at west base Mount Hamilton Range). (*Cotyledon laxa* var. *Setchellii* Jepson; *Dudleya Setchellii* Brit. and Rose.) Occasional on cliffs across range. There is apparently no geographic segregation of this variety and the preceding; both as known appear to be limited to the Mount Hamilton Range and the adjacent Santa Clara Valley, and are here regarded as questionably distinct.

#### SAXIFRAGACEAE

*SAXIFRAGA CALIFORNICA* Greene. (*S. virginensis* var. *californica* Jepson; *Micranthes californica* Small.) Occasional on moist, wooded slopes across range.

*LITHOPHRAGMA AFFINIS* Gray. Occasional to abundant across range on moist, wooded slopes.

*LITHOPHRAGMA CYMBALARIA* Torr. and Gray. Arroyo del Puerto on moist, rocky slope, H. K. Sharsmith 1630 (UC). This species has been known hitherto from hills mostly near the coast from Monterey County to San Diego County; the above collection thus represents a long extension of known range.

*LITHOPHRAGMA HETEROPHYLLA* (Hook. and Arn.) Torr. and Gray var. *SCABRELLA* (Greene) Jepson. (*L. scabrella* Greene.) Wooded slopes, west side of range.

*HEUCHERA MICRANTHA* Dougl. var. *PACIFICA* Rosend. and Butters. Niles Canyon (extreme northwest margin of Mount Hamilton Range), Mason 3237 (UC). In the central Coast Ranges more typically an element of the outer Coast Ranges.

*RIBES AUREUM* Pursh var. *GRACILLIMUM* (Cov. and Britt.) Jepson. Occasional at stream margins, interior of range.

*RIBES SANGUINEUM* Pursh var. *GLUTINOSUM* (Benth.) Loud. (*R. glutinosum* Benth.) Wooded slopes, Mount Hamilton.

*RIBES MALVACEUM* Smith. Occasional on wooded slopes or in chaparral across range.

*RIBES QUERCETORUM* Greene. Occasional on brushy or wooded canyon slopes, interior and east side of range, its approximate northern limit of distribution.

*RIBES CALIFORNICUM* Hook. and Arn. Dry, rocky slopes, west side and interior of range.

*RIBES AMARUM* McCl. Brush slopes, west side of range. Pyramid Rock, Hendrix 800 (VTM); Smith Creek, Lundh 37 (VTM); Mount Hamilton, H. K. Sharsmith 3346 (UC). Mainly found in southern California in the San Bernardino and San Gabriel mountains; occurring northward in the southern Sierra Nevada, and in the Santa Lucia Mountains of the South Coast Ranges. The specimens cited above agree closely not only with *R. amarum*, but also with *R. Menziesii* var. *hystriculium* Jepson (Fl. Calif. 2:156, 1936) of Mount Diablo. Apparently these two units are closely related. In *R. amarum* the hypanthium is described as longer than broad and the sepals are ligulate; in *R. Menziesii* and allies the hypanthium is described as broader than long, less than half the length of the sepals, and the sepals are lanceolate. The Mount Hamilton Range specimens agree with *R. amarum* in general characteristics of flower and fruit, and have a hypanthium about as broad as long, but at least half the length of the sepals, and the sepals are more or less ligulate.

*RIBES SPECIOSUM* Pursh. Wooded slopes, west side of range.

## PLATANACEAE

*PLATANUS RACEMOSA* Nutt. Abundant in canyon bottoms in localized areas. Very abundant in Arroyo Mocho at north margin of range; not seen in interior of range or in Arroyo del Puerto.

## ROSACEAE

*HOLODISCUS DISCOLOR* Maxim. Wooded slopes, west side of range.

*RUBUS VITIFOLIUS* Cham. and Schlecht. Brushy or wooded slopes, west side of range.

*POTENTILLA GLANDULOSA* Lindl. subsp. *TYPICA* Keck. (*P. glandulosa* var. *Wrageliana* Wolf; *Drymocallis glandulosa* (Lindl.) Rydb.) San Antonio Valley.

*ROSA CALIFORNICA* Cham. and Schlecht. Common in interior of range in canyon bottoms.

*ROSA GYMNOCARPA* Nutt. Santa Isabella Creek. Predominately an outer Coast Range species in central California; absent or infrequent in the inner South Coast Ranges.

*ALCHEMILLA OCCIDENTALIS* Nutt. (*A. arvensis* of authors, non Scop.; *A. cuneifolia* Nutt.) Grassy slopes across range, infrequent.

*CERCOCARPUS BETULOIDES* Nutt. (*C. betulaeifolius* Nutt.) Occasional chaparral constituent across range.

*ADENOSTOMA FASCICULATUM* Hook. and Arn. Dominant chaparral species of interior of range, sometimes forming extensive pure stands.

*OSMARONIA CERASIFORMIS* (Torr. and Gray) Greene. Occasional element of soft chaparral, west side and interior of range.

*PRUNUS EMARGINATA* (Dougl.) Walp. (*Cerasus emarginata* Dougl.) On brushy slopes, west side of range.

*PRUNUS VIRGINIANA* L. var. *DEMISSA* (Nutt.) Torr. (*Cerasus demissa* Nutt.; *Padua demissa* Roem.) Occasional on north-facing slopes, west side and interior of range.

*PRUNUS ILICIFOLIA* (Nutt.) Walp. (*Cerasus ilicifolia* Nutt.) Occasional in chaparral as low shrub, or forming trees 20-30 feet high on moist, north-facing slopes; interior of range.

*PRUNUS SUBCORDATA* Benth. Forming thickets on north-facing slopes, interior of range.

*PHOTINIA ARBUTIFOLIA* (Ait.) Lindl. An infrequent chaparral component across range.

\**PYRUS MALUS* L.? Forming a single thicket, west side Mount Hamilton near summit, *H. K. Sharsmith 1090* (UC); sterile.

*AMELANCHIER ALNIFOLIA* Nutt. Wooded slopes, west side and interior of range.

## LEGUMINOSAE

*PROSOPIS CHILENSIS* (Molina) Stuntz. (*P. juliflora* DC. var. *glandulosa* (Torr.) Cockerell.) Tesla, Corral Hollow, *Mason* in 1935 (UC), *Ferris* 7882 (S). A desert species occurring sparingly at north base of Tehachapi Mountains, and at two or three isolated localities in the inner South Coast Ranges, Corral Hollow representing its known northern limit.

*THERMOPSIS MACROPHYLLA* Hook. and Arn. (*T. californica* Wats.; *T. californica* var. *velutina* Greene.) Dry slopes, west side Mount Hamilton.

*PICKERINGIA MONTANA* Nutt. Near Round Mountain, *Lundh* 20 (VTM). To be expected as a frequent xerophytic chaparral element of interior and east side of range, but apparently uncommon.

*LUPINUS ALBIFRONS* Benth. (*L. albifrons* var. *collinus* Greene; *L. collinus* Heller.) Frequent on dry, exposed slopes across range.

*LUPINUS FORMOSUS* Greene. (*L. Pendletonii* Heller, Muhl. 2:295. 1907; type from Mount Hamilton, *Heller* 8610.) Grasslands, San Antonio Valley.

*LUPINUS RIVULARIS* Dougl. (*L. latifolius* Agardh.) Openly wooded slopes, Mount Hamilton.

*LUPINUS BICOLOR* Lindl. (*L. bicolor* var. *microphyllus* C. P. Smith.) Frequent vernal annual on grassy slopes across the range.

*LUPINUS SUCCULENTUS* Dougl. Occasional on hillslopes or in valley flats across range.

*LUPINUS DENSIFLORUS* Benth. (*L. microcarpus* Sims var. *densiflorus* Jepson.) Frequent on grassy slopes or in flood beds of streams, across range.

*LUPINUS MICROCARPUS* Sims. (*L. subvexus* C. P. Smith; *L. subvexus* var. *phoeniceus* C. P. Smith, Bull. Torr. Bot. Club 44:405. 1917, type from west side Mount Hamilton, Heller 8652.) Frequent on grassy slopes across range. Following Jepson (Fl. Calif. 2:278. 1936) *L. subvexus* is here considered as conspecific with the Chilean *L. microcarpus*. Jepson, op. cit., treats *L. densiflorus* as a variety of *L. microcarpus*, but it is here considered as a distinct species (see above). Both *L. densiflorus* and *L. microcarpus* occur abundantly in the Mount Hamilton Range and are easily distinguished in the field and from dried material. *Lupinus densiflorus* is usually larger than *L. microcarpus*, less villous, and with more fistulose stems; the verticels are secund in fruit in *L. densiflorus*, but not in *L. microcarpus*; and the flowers are yellow in *L. densiflorus* (occasionally tinged with pink or blue), and blue in *L. microcarpus*.

\**MEDICAGO LUPULINA* L. Occasional, west side of range.

\**MEDICAGO HISPIDA* Gaertn. (*M. denticulata* Willd.) Occasional, west side of range.

\**MEDICAGO APICULATA* Willd. Arroyo del Puerto.

\**MELILOTUS ALBA* Desr. Arroyo del Puerto.

*TRIFOLIUM FUCATUM* Lindl. Occasional along streams, interior of range.

*TRIFOLIUM AMPLECTENS* Torr. and Gray. Occasional on hillslopes, interior and east side of range.

*TRIFOLIUM DEPAUPERATUM* Desv. Occasional in valleys or canyon bottoms, interior of range.

*TRIFOLIUM TRIDENTATUM* Lindl. Frequent on hillslopes and valleys across range. *H. K. Sharsmith 1033* (UC). Copernicus Peak, is remarkable for its very narrow leaflets, and internodes so short that the dry stipules cover the stems; *H. K. Sharsmith 3710* (UC), a later collection from the same locality, is much less extreme as to these points.

*TRIFOLIUM OBTUSIFLORUM* Hook. (*T. roscidum* Greene.) Occasional in moist areas across range.

*TRIFOLIUM WORMSKJOLDII* Lehm. (*T. involucratum* Ortega.) Bog, north side Mount Hamilton.

*TRIFOLIUM VARIEGATUM* Nutt. Moist areas, west side and interior of range.

*TRIFOLIUM OLIGANTHUM* (Nutt.) Steud. Infrequent across range on wooded slopes.

*TRIFOLIUM CYATHIFERUM* Lindl. Occasional in flood bed of Santa Isabella Creek. North base Mount Hamilton, *H. K. Sharsmith 3661* (UC); east base Mount Hamilton, *H. K. Sharsmith 1153* (UC); east base Mount Santa Isabella, *H. K. Sharsmith 3733* (UC). The above collections represent the first record of this northern species in the South Coast Ranges.

*TRIFOLIUM BARBIGERUM* Torr. Grassland, Mount Day Ridge.

*TRIFOLIUM MICRODON* Hook. and Arn. Dry slopes, interior and west side of range.

*TRIFOLIUM MICROCEPHALUM* Pursh. Meadowy areas, or wooded slopes, west side of range.

*TRIFOLIUM BIFIDUM* Gray. Grassy slopes, west side of range.

*TRIFOLIUM CILIOLATUM* Benth. (*T. ciliatum* Nutt., non Clarke.) Occasional across range on grassy slopes or valley flats.

*TRIFOLIUM GRACILENTUM* Torr. and Gray. Occasional across range on grassy slopes or valley flats.

*TRIFOLIUM MACRAEI* Hook. and Arn. Mount Hamilton, *Elmer 4673* (UC). Typically an element of the immediate coast.

*TRIFOLIUM DICHOTOMUM* Hook. and Arn. Arroyo del Puerto.

*TRIFOLIUM DICHOTOMUM* var. *TURBINATUM* Jepson. Grassy slopes or rocky areas. Mount Hamilton. Distinguished from the species by its low stature and turbinate or ovate heads, and according to Jepson (Fl. Calif. 2:310. 1936) restricted to Mount Hamilton and Mount Tamalpais.

*TRIFOLIUM ALBOPURPUREUM* Torr. and Gray. Frequent on grassy slopes across range.

*TRIFOLIUM OLIVACEUM* Greene var. *GRISEUM* Jepson. Grassland, San Antonio Valley.

*LOTUS CRASSIFOLIUS* (Benth.) Greene. Grassland, Mount Hamilton.

LOTUS STRIGOSUS (Nutt.) Greene. Rocky, openly wooded slopes, Arroyo del Puerto.

LOTUS MICRANTHUS Benth. Grassy slopes, west side Mount Hamilton.

LOTUS AMERICANUS (Nutt.) Bisch. Occasional on grassy slopes across range.

LOTUS SUBPINNATUS Lag. Common in grassland or in flood beds of streams across range.

LOTUS HUMISTRATUS Greene. Common in grassland or in flood beds of streams across range.

LOTUS RUBRIFLORUS H. K. Sharsmith, Madroño 6:56-58. 1941. Rolling hills at north end Adobe Valley, Mount Hamilton Range, Carter and Sharsmith 3544 (type UC!), plants in flower; Carter and Morrison 1403 (UC) topotype, plants in fruit. Known only at the type locality, but within the one known colony the plants are abundant; a distinctive species.

LOTUS SCOPARIUS (Nutt.) Ottley. Infrequent on rocky slopes across range.

PSORALEA MACROSTACHYA DC. (*Hoita macrostachya* Rydb.) Moist areas, near summit Mount Hamilton.

PSORALEA PHYSODES Dougl. (*Hoita physodes* Rydb.) Wooded slopes, west side of range.

PSORALEA CALIFORNICA Wats. (*Pediomelum californicum* Rydb.) Unstable talus, east side of range.

GLYCYRRHIZA LEPIDOTA Pursh. Hillslopes or valley flats, infrequent, interior of range.

ASTRAGALUS OXYPHYSUS Gray. Type from Arroyo del Puerto, Mount Hamilton Range, Brewer 1259 (isotype UC!). Arroyo del Puerto, H. K. Sharsmith 1554, 1773 (UC), Hoover 851 (UC); Crow's Creek, Elmer 4358 (WSC). The Arroyo del Puerto collections represent topotypes, and are apparently the first recollections from this area since Brewer collected the type in 1862. The Mount Hamilton Range is the known northern limit of the species.

ASTRAGALUS DOUGLASII Gray? Interior of range on grassy slopes. Arroyo Bayo, H. K. Sharsmith 1901, 3466 (UC). Questionably referable to *A. Douglasii*; in the absence of mature pods a positive determination is difficult or impossible.

ASTRAGALUS DIDYMOCARPUS Hook. and Arn. Exposed slopes, east side of range.

ASTRAGALUS GAMBELIANUS Sheld. Common across range on grassy slopes.

\*VICIA SATIVA L. Grassy slope, Hall's Valley.

VICIA AMERICANA Muhl. var. TRUNCATA (Nutt.) Brewer. (*V. truncata* Nutt.) Occasional on wooded slopes west side and interior of range.

VICIA CALIFORNICA Greene. Wooded slopes, Mount Hamilton. Closely allied to *V. americana* var. *truncata*, but more villous, and the plants usually only 5-11 inches tall instead of 2-3 feet. The large colonies of *V. californica* are uniformly low in the Mount Hamilton area, and easily distinguished from *V. americana* var. *truncata*.

LATHYRUS BOLANDERI Wats. subsp. QUERCETORUM (Heller) Bradshaw. (*L. vestitus* of authors; *L. quercetorum* Heller, Muhl. 2:290, 1907, type from near summit of Mount Hamilton, Heller 8623.) Common on wooded slopes, west side of range, extending into the interior in favorable habitats.

#### LINACEAE

LINUM CLEVELANDII Greene. (*Hesperolinon Clevelandii* Small.) Occasional in large colonies on rocky slopes in chaparral or on unstable talus, serpentine rock, Red Mountains. Arroyo del Puerto, H. K. Sharsmith 3748, 3788 (UC), Carter 862 (UC); Adobe Creek, H. K. Sharsmith 3755 (UC); Colorado Creek, H. K. Sharsmith 3801 (UC). Hitherto considered as restricted to chaparral serpentine areas of Lake County, where it is most highly developed, and adjacent areas in Napa and Mendocino counties. The Red Mountains collections thus represent a significant extension of known range.

LINUM MICRANTHUM Gray. (*Hesperolinon micranthum* Small.) Occasional in chaparral across range.

LINUM CALIFORNICUM Benth. (*Hesperolinon californicum* Small.) Rocky slopes in shale or serpentine, east side of range.

LINUM SPERGULINUM Gray. Bald Peak, Dudley 4197 (S).



## GERANIACEAE

GERANIUM CAROLINIANUM L. Grassy slopes, west side of the range.

\*GERANIUM DISSECTUM L. Grassy areas, west side and interior of range.

ERODIUM MACROPHYLLUM Hook. and Arn. Orestimba Canyon, Brewer 1280 (UC). According to Jepson (Fl. Calif. 2:407. 1936), this "is an extremely rare plant, both as to stations and individuals."

\*ERODIUM BOTRYS (Cav.) Bertol. Grassy hillsides, west side of range.

\*ERODIUM MOSCHATUM (L.) L'Her. Across range, but most abundant on the lower, cultivated slopes of west side.

\*ERODIUM CICUTARIUM (L.) L'Her. Common in depauperate form on dry and sparsely grassy hillsides across range.

## LIMNANTHACEAE

LIMNANTHES DOUGLASHI R. Br. (*Floerkea Douglasii* Baill.) Occasional in moist valley flats, west side and interior of range.

## EUPHORBIACEAE

EREOMOCARPUS SETIGERUS (Hook.) Benth. (*Croton setigerus* Hook.) Common autumnal species of the dryer plains and hillsides across range.

EUPHORBIA SERPYLLIFOLIA Pers. (*Chamaesyce serpyllifolia* Small.) Occasional, valleys and hillsides, interior and east side of range.

EUPHORBIA OCELLATA Dur. and Hilg. var. TYPICA Wheeler. Canyon slopes or dry creek beds, east side of range.

EUPHORBIA DICTYOSPERMA Fisch. and Mey. Openly wooded slopes, occasional across range.

EUPHORBIA CRENULATA Engelm. Moist sand, Santa Isabella Creek.

## CALLITRICHACEAE

CALLITRICH MARGINATA Torr. Sag pond, Atroyo Mocho.

CALLITRICH PALUSTRIS L. Sag pond, Mount Day Ridge.

## ANACARDIACEAE

TOXICODENDRON DIVERSILOBUM (Torr. and Gray) Greene. (*Rhus diversiloba* Torr. and Gray). Frequent across the range on canyon slopes.

## ACERACEAE

ACER MACROPHYLLUM Pursh. In ravines or at stream margins, west side of range.

## SAPINDACEAE

AESCULUS CALIFORNICA (Spach) Nutt. Occasional on north facing slopes across range.

## RHAMNACEAE

RHAMNUS CALIFORNICA Esch. subsp. TOMENTELLA (Benth.) Wolf. (*R. tomentella* Benth.; *R. californica* var. *tomentella* Brew. and Wats.) Common on open slopes or sometimes in chaparral, west side and interior of range. Distinguished from the subspecies *typica* Wolf by narrowly elliptical leaves which are tomentose beneath; characteristic of the inner Coast Ranges whereas subspecies *typica* is more maritime. On Mount Hamilton, however, a form occurs which is intermediate between subspecies *typica* and subspecies *tomentella*. It is found only in dense shade, and has the broad, thin leaves of subspecies *typica*; the leaves appear almost glabrous beneath, but when carefully examined they reveal a slight tomentum such as is characteristic of subspecies *tomentella*. The following collection represents this shade form: Santa Isabella Creek, H. K. Sharsmith 3659 (UC), undershrub beneath dense growth of *Acer macrophyllum* and *Arbutus Menziesii*. A similar shade form was noted by Greene (*Erythra* 1: 82. 1893) at Joaquin (Murietta) Springs.

RHAMNUS CROCEA Nutt. subsp. ILICIFOLIA (Kell.) Wolf. (*R. ilicifolia* Kell.; *R. crocea* var. *ilicifolia* Greene.) On wooded slopes or in chaparral, occasional across range.

*CEANOTHUS INTEGERRIMUS* Hook. and Arn. Single shrub in dense shade, Santa Isabella Creek, *H. K. Sharsmith 3660* (UC).

*CEANOTHUS LEUCODERMIS* Greene. (*C. divaricatus* of authors, non Nutt.) Chaparral constituent of interior and east side of range, most common in Red Mountains area.

*CEANOTHUS SOREDIATUS* Hook. and Arn. Infrequent chaparral constituent across range. A specimen from Mount Sizer, *Hendrix 747* (VTM), has leaf characteristics of both *C. soledatus* and *C. dentatus* Torr. and Gray; according to the collector's note it appeared to be a hybrid between these two species, but the material is without flowers or fruits and positive determination is difficult.

*CEANOTHUS CUNEATUS* (Hook.) Nutt. Next to *Adenostoma fasciculatum* the most abundant chaparral element; interior and east side of range. Greene (*Erythea* 1:79. 1893) comments that the genus *Ceanothus* "seems to be wholly absent from Mount Hamilton." Greene must have confined his botanical activities on Mount Hamilton entirely to the west side and summit areas of the mountain, for *C. cuneatus* is extremely abundant on the east slope below 3500 feet.

*CEANOTHUS FERRISAE* McMinn, *Madroño* 2:89. 1933. Type from above Coyote Creek, Madrone Springs road, Mount Hamilton Range, *Abrams 6626* (S!). Known only from the west slope of the Mount Hamilton Range near Madrone Springs, and from a few stations in the Santa Cruz Mountains; it is related to *C. cuneatus*, but is distinguished by larger, more elliptical, and toothed leaves.

## VITACEAE

*VITIS CALIFORNICA* Benth. Isolated localities, west side of range.

## MALVACEAE

*SIDALCEA DIPLOSCYPHA* (Torr. and Gray) Gray. Wooded areas, east side Mount Hamilton.

*SIDALCEA MALVAEFLOA* (DC.) Gray. Grassland near Hall's Valley.

*MALVASTRUM FREMONTII* Torr. var. *CERCOPHORUM* Rob., type from Arroyo del Vallé, Mount Hamilton Range, Greene. Occasional on dry slopes of interior, more abundant on east side of range.

*MALVASTRUM PARRYI* Greene. Corral Hollow.

## ELATINACEAE

*ELATINE BRACHYSPERMA* Gray. Sag pond, Mount Day Ridge.

*ELATINE CALIFORNICA* Gray. Sag pond, Mount Day Ridge.

## VIOLACEAE

*VIOLA DOUGLASHI* (Hook.) Steud. Frequent in early spring on grassy slopes, west side and interior of range.

*VIOLA SHELTONII* Torr. Rocky chaparral slope, near summit of Copernicus Peak, *H. K. Sharsmith 1040* (UC). A fragmentary specimen collected after the plants had shed their seeds, but leaf shape and underground parts make its identity unquestionable. *Viola Sheltonii* has not been reported before from the South Coast Ranges except from Mount Diablo. It occurs at medium elevations in the North Coast Ranges, Sierra Nevada, and in the mountains of southern California, and might well be expected in the South Coast Ranges.

*VIOLA PURPUREA* Kell. Frequent on rocky, openly wooded slopes across range.

*VIOLA PEDUNCULATA* Torr. and Gray. Open grassy slopes, interior and west side of range.

## LOASACEAE

*MENTZELIA LAEVICAULIS* (Dougl.) Torr. and Gray. Dry floodbeds, occasional across range.

*MENTZELIA LINDLEYI* Torr. and Gray subsp. *TYPICA* Wolf. (*M. Lindleyi* Torr. and Gray; *Acrolasia aurea* Rydb.) Dry, rocky slopes across range, but most abundant in interior and on east side. The subspecies reaches its highest development in the Mount Hamilton Range, presumably the type locality according to Wolf (*Occasional Papers, Rancho Santa Ana Bot. Gard. series 1, No. 2. 69-73. 1938*).

MENTZELIA MICRANTHA (Hook. and Arn.) Torr. and Gray. Occasional on open slopes, west side of range.

MENTZELIA DISPERSA Wats. Dry open slopes or in chaparral, interior and east side of range.

MENTZELIA GRACILIENIA Torr. and Gray. Canyon slopes, east side of range. A southern California and Great Basin species which reaches its northern limit in the Mount Hamilton Range.

#### DATISACEAE

DATISCA GLOMERATA (Presl.) Baill. Occasional; wooded slopes, Mount Hamilton.

#### LYTHRACEAE

LYTHRUM ADSURGENS Greene. Moist sand, Santa Isabella Creek.

#### ONAGRACEAE

ZAUSCHNERIA CALIFORNICA Presl. Rocky slopes, occasional across range.

EPILOBIUM MINUTUM Lindl. Occasional, interior and east side of range, in flood beds of streams or on talus.

EPILOBIUM PANICULATUM Nutt. Occasional on grassy slopes across range.

BOISDUVALIA DENSIFLORA (Lindl.) Wats. (*B. bipartita* Greene, *Erythra* 3:119. 1895; type from Arroyo del Vallé, Mount Hamilton Range, Greene.) Occasional in moist areas, west side and interior of range.

BOISDUVALIA STRICTA (Gray) Greene. Moist gully, San Antonio Valley.

CLARKIA RHOMBOIDEA Dougl. Wooded slopes, east side Mount Hamilton.

CLARKIA ELEGANS Dougl. Frequent across range on exposed slopes.

CLARKIA CONCINNA (Fisch. and Mey.) Greene. Moist wooded slopes, west side and interior of range.

CLARKIA BREWERI (Gray) Greene. (*C. Saxean.* Greene.) Rocky slopes mainly of unstable shale talus; summit areas across range, most abundant on east side. Type from Mount Oso, Mount Hamilton Range, *Brewer*. In the Mount Hamilton Range the colonies of this central Coast Range endemic are highly localized and usually small, although the individuals may be very abundant within a colony. When the plants are in full bloom some of the colonies high on the steep shale slopes of Arroyo del Puerto can be seen at a distance of one-half mile or more, due to the abundance of plants within the colony and the vivid pink of the large flowers.

GODETIA AMOENA (Lehm.) Don. (*G. rubicunda* Lindl.) Frequent in grassland, west side and interior of range.

GODETIA QUADRIVULNERA (Dougl.) Spach. Dry hillsides, west side and interior of range.

GODETIA QUADRIVULNERA var. *ELMERI* Jepson. (*G. purpurea* Don var. *Elmeri* Jepson; *G. purpurea* var. *parviflora* (Wats.) Hitchc.) Occasional, grassy slopes, west side of range.

GODETIA EPILOBIODES (Nutt.) Wats. (*Clarkia epilobioides* Nels. and Macbr.; *G. epilobioides* var. *modesta* (Jepson) Jepson.) Wooded slopes, interior and east side of range.

OENOTHERA DELTOIDES Torr. and Frem. var. *COGNATA* (Jeps.) Munz, type from Corral Hollow, Mount Hamilton Range, *Brewer* 1217. Corral Hollow.

OENOTHERA MICRANTHA Hornem. var. *JONESII* (Levl.) Munz. (*Sphaerostigma micranthum* var. *Jonesii* Nelson; *Oenothera hirtella* Greene.) Occasional in chaparral or rocky flood beds, interior and east side of range. Variety *typica* Munz is found mainly on the immediate coast, but Munz (Bot. Gaz. 85:262. 1928), in discussing the frequent intergradations, cites the following as an intergrade between variety *typica* and variety *Jonesii*: Mount Hamilton-Livermore road, *Bacigalupi* in 1923 (S).

OENOTHERA CONTORTA Dougl. var. *STRIGULOSA* (Fisch. and Mey.) Munz. Dry slopes or in chaparral, interior and east side of range.

OENOTHERA DECORTICANS (Hook. and Arn.) Greene var. *TYPICA* Munz. *O. decorticans* of authors, *O. alyssoides* var. *decorticans* Jepson.) Unstable talus, east side of range. A desert dwelling species which reaches its northern extremity in the Mount Hamilton Range.

## ARALIACEAE

*ARALIA CALIFORNICA* Wats. Wooded gullies below springs, east slope Mount Hamilton. Characteristic of the outer Coast Ranges rather than the inner.

## UMBELLIFERAE

*SANICULA CRASSICAULIS* Poepp. (*S. Menziesii* Hook. and Arn.) West slope Mount Hamilton.

*SANICULA BIPINNATIFIDA* Dougl. Occasional on open grassy slopes across range.

*SANICULA BIPINNATA* Hook. and Arn. Occasional on open grassy slopes, west side and interior of range.

*SANICULA TUBEROSA* Torr. Occasional on openly wooded slopes, west side and interior of range.

*SANICULA SAXATILIS* Greene. Rocky opening in chaparral, northeast ridge of Copernicus Peak, *H. K. Sharsmith 923* (UC); unstable talus, east side Mount Hamilton, *Bowerman 924* (UC), *H. K. Sharsmith 1925* (UC). *Sanicula saxatilis* Greene is among the least known and most narrowly restricted of the species endemic to the central Coast Ranges. For many years this distinctive species was known only from rocky crests near the summit of Mount Diablo, the northernmost peak of the South Coast Ranges, where it was first collected by Greene in 1893. Only three or four collections have been made from Mount Diablo since. *Sanicula saxatilis* was found first on Mount Hamilton by Bowerman. In the two Mount Hamilton localities known for the species, the plants of the colony grow within a sharply limited area; the individuals are scattered and not abundant, and are restricted to almost barren, talus "islands" in the chaparral. The fleshy roots are tuberous, and are wedged between the rocks and often much distorted.

*OSMORHIZA BRACHYPODA* Torr. Infrequent on wooded slopes, Mount Hamilton.

*OSMORHIZA NUDA* Torr. Wooded slopes, west side of range.

*DAUCUS PUSILLUS* Michx. Infrequent on rocky, openly wooded slopes across range.

*APIASTRUM ANGUSTIFOLIUM* Nutt. Infrequent, east side of range.

*CAUCALIS MICROCARPA* Hook. and Arn. Occasional across range on grassy slopes.

*BOWLESIA INCANA* Ruiz and Pavon. (*B. septentrionalis* Coult. and Rose.) Infrequent on moist shaded banks of streams across range.

\**CONIUM MACULATUM* L. In dense stands along roadside where natural vegetation was cleared by burning, Grand View.

*PERIDERIDIA GAIRDNERI* (Hook. and Arn.) Mathias. (*Carum Gairdneri* Gray.) Steep, rocky slope, Santa Isabella Valley.

*PERIDERIDIA CALIFORNICA* (Torr.) Nels. and Macbr. (*Eulophus californicus* Coult. and Rose.) Frequent along stream margins, interior of range.

*DEWEYA HARTWEGII* Gray. (*Velaea Hartwegii* Coult. and Rose.) Infrequent; wooded slopes, west side and interior of range. A widely distributed, but locally rare species.

*DEWEYA KELLOGGII* Gray. (*Velaea Kelloggii* Coult. and Rose.) Wooded, rocky slopes, Arroyo Bayo. Like the preceding, widely distributed but locally rare, the known stations scattered.

*LEPTOTAENIA CALIFORNICA* Nutt. Occasional on wooded or brushy slopes, interior of range.

*LOMATIUM CARULIFOLIUM* (Hook. and Arn.) Coult. and Rose. (*Peucedanum carulifolium* Torr. and Gray.) Rocky summit areas, Mount Hamilton.

*LOMATIUM UTRICULATUM* (Nutt.) Coult. and Rose. Occasional on rocky, openly wooded slopes across the range.

*LOMATIUM MACROCARPUM* (Hook. and Arn.) Coult. and Rose. Common on openly wooded, grassy slopes, interior and east side of range.

*LOMATIUM DASYCARPUM* (Torr. and Gray) Coult. and Rose. (*Peucedanum tomentosum* acc. Greene, *Erythra 1:88*, 1893, non Benth.) Occasional in dry open slopes across range.

*LOMATIUM NUDICAULE* (Pursh) Coult. and Rose. Occasional in interior of range on dry, open slopes.

*ANGELICA TOMENTOSA* Wats. Moist soil, spring margins, east slope of Mount Hamilton.

*ERYNGIUM VASEYI* Coult. and Rose var. *CASTRENSE* (Jepson) Hoover ex Mathias and Constance. Occasional in drying pools, interior of range.

## GARRYACEAE

*GARRYA FREMONTII* Torr. Chaparral slopes, summits of peaks on west side of range and through interior. The Mount Hamilton Range material is atypical according to Bacigalupi in that the leaves are hairy beneath, with straight, appressed hairs, rather than glabrous.

*GARRYA CONGDONI* Eastw. (*G. flavescens* var. *venosa* Jepson.) Canyon slopes of serpentine rock, west side of range and in Red Mountains. A little known species restricted to the inner Coast Ranges from Tehama County and Lake County to San Benito County, also in the foothills of the central Sierra Nevada. Only on serpentine in the Mount Hamilton Range.

## CORNACEAE

*CORNUS GLABRATA* Benth. In thickets along stream margins, west side and interior of range.

*CORNUS STOLONIFERA* Michx. var. *CALIFORNICA* (C. A. Mey.) McMinn. (*C. pubescens* var. *californica* Coult. and Evans; *C. californica* var. *pubescens* Macbr.) Occasional at stream margins, west side and interior of range.

## ERICACEAE

*ARBUTUS MENZIESII* Pursh. Occasional, wooded slopes on west side of range. An outer Coast Range species which is rare in the inner Coast Ranges.

*ARCTOSTAPHYLOS GLAUCA* Lindl. (*A. manzanita* Parry acc. Greene, *Erythea* 1:92. 1893.) Frequent in chaparral across range.

*ARCTOSTAPHYLOS GLANDULOSA* Eastw. var. *CAMPBELLAE* (Eastw.) Adams. (*A. Campbellae* Eastw., type from Mount Hamilton, *Campbell* in 1922 (CA); *A. tomentosa* Dougl. acc. Greene, *Erythea* 1:92. 1893.) Frequent on summit areas of west side of range, occasional in chaparral of interior; restricted to the Mount Hamilton Range.

## PRIMULACEAE

*DODECATHEON HENDERSONII* Gray. Frequent on openly wooded slopes across range.

*DODECATHEON HENDERSONII* Gray var. *BERNALINUM* (Greene) Jepson. Hillsides and valley flats across range, most frequent in interior; flowering in early spring, the dense colonies often covering large areas. Mount Hamilton, *H. K. Sharsmith* 530 (UC); Arroyo Mocho, *H. K. Sharsmith* 1460 (UC); Arroyo del Puerto, *H. K. Sharsmith* 1654 (UC). According to H. L. Mason (oral communication), this variety is more properly placed under *D. Clevelandii* Greene, which it resembles except for smaller habit, and shorter, more obtuse anthers.

*ANDROSACE OCCIDENTALIS* Pursh var. *ACUTA* (Greene) Jepson. (*A. acuta* Greene.) Rocky areas, interior and east side of range; infrequent. Arroyo Bayo, *H. K. Sharsmith* 3067 (UC); Red Mountains, *H. K. Sharsmith* 1681 (UC); Arroyo del Puerto, *H. K. Sharsmith* 1585 (UC). Widely distributed but rare, the few known stations very isolated; not before recorded from the Mount Hamilton Range. This variety is recognized as a distinct species by Munz (Man. S. Calif. Bot. 371. 1935), but in such a polymorphic genus as *Androsace*, the distinctions between *A. occidentalis* of the eastern states and this Californian representative do not seem sufficient to warrant specific segregation. In variety *acuta* the plants are more delicate, the umbels have fewer flowers, the pedicels are longer, and the calyx teeth are much narrower, almost subulate, but *A. occidentalis* grades toward the variety in all these characteristics.

\**ANAGALLIS ARVENSIS* L. Grasslands, west slope Mount Hamilton.

## OLEACEAE

*FRAXINUS DIPETALA* Hook. and Arn. Headwaters Arroyo del Puerto.

*FORESTIERA NEOMEXICANA* Gray. Forming thickets near stream margin, headwaters Arroyo Mocho, *H. K. Sharsmith* 1715 (UC). Mainly of the southwestern United States, occurring sparingly northward in the inner South Coast Ranges to the Mount Hamilton Range.

## GENTIANACEAE

*CENTAURIUM FLORIBUNDUM* Rob. (*Erythraea floribundum* Benth.) Grassy slopes, east side of range.

## APOCYNACEAE

*APOCYNUM CANNABINUM* L. var. *GLABERRIMUM* DC. Occasional at stream margins, interior of range.

## ASCLEPIADACEAE

*ASCLEPIAS MEXICANA* Cav. Occasional on dry hills, west side and interior of range.

*ASCLEPIAS CALIFORNICA* Greene. Sparingly distributed across the range on open, dry chaparral slopes.

## CONVOLVULACEAE

*CONVOLVULUS MALACOPHYLLUS* Greene. (*C. villosus* (Kell.) Gray, non Pers.; *C. villosus* var. *pedicellata* Jepson; *C. collinus* of authors, non Greene.) Infrequent across range on rocky slopes in chaparral, areas of serpentine rock. The South Coast Range material of *C. malacophyllus* corresponds to *C. villosus* var. *pedicellata* Jepson. Although there is geographical segregation, the variety has a minor morphological basis. If it were to be recognized, a new combination under *C. malacophyllus* would be necessary.

*CONVOLVULUS CALIFORNICUS* Choisy. (*C. subacaulis* (Hook. and Arn.) Greene, non Buch.-Ham ex Wall.) Dry slopes, west side of range.

*CUSCUTA SUBINCLUSA* Dur. and Hilg. Parasitic on various shrubs, occasional across range.

## POLEMONIACEAE

*COLLOMIA GRANDIFLORA* Dougl. Occasional on wooded slopes, west side of range.

*COLLOMIA DIVERSIFOLIA* Greene. Serpentine talus Adobe Creek canyon, *H. K. Sharsmith 3584* (UC). Known hitherto by only four collections from Mendocino, Colusa, and Lake Counties of the North Coast Ranges. This represents one of the species common to serpentine talus in Lake County and in the Red Mountains of the Mount Hamilton Range, but not occurring between.

*PHLOX GRACILIS* (Dougl.) Greene. (*Gilia gracilis* Hook.) Frequent spring annual, grassy slopes across range.

*NAVARRETIA ABRAMSI* Elmer. Frequent in rocky soil of chaparral areas, interior and east side of range. The Mount Hamilton Range collections add greatly to our knowledge of this previously little known species, as discussed in a separate paper (Sharsmith, H. K., Amer. Midl. Nat. 32:510-512. 1944.)

*NAVARRETIA PUBESCENS* (Benth.) Hook. and Arn. Occasional in grasslands across range.

*NAVARRETIA INTERTEXTA* (Benth.) Hook. (*Gilia intertexta* Steud.) Occasional near stream margins or at vernal pools, interior of range.

*NAVARRETIA MELLITA* Greene. Occasional in chaparral, interior of range.

*HUGELIA FILIFOLIA* (Nutt.) Jepson. (*Gilia filifolia* Nutt. var. *typica* Craig.) Chaparral ridge between Arroyo Bayo and San Antonio Valley, *H. K. Sharsmith 3299* (UC). A widely ranging species, found throughout the more arid portions of western United States. The Mount Hamilton Range material corresponds to the typical phase of the species, that common to coastal southern California from Santa Barbara County to northern Lower California. The above collection and a previously unrecorded one from Lake County of the North Coast Ranges (Near Kelseyville, Schulthess in 1931, UC) represent long extensions northward of the species' known range.

*Hugelia filifolia* is closely related to *Navaretia Abramsii*. In the Mount Hamilton Range *H. filifolia* was found in the same type of habitat as that which *N. Abramsii* frequents, and *N. Abramsii* was collected from the same locality as the collection 3299 cited above. The plants of *H. filifolia*, although superficially similar to those of *N. Abramsii*, were distinguished in the field by their taller size, less branched and more erect stems, and narrower flower clusters.

*HUGELIA PLURIFLORA* (Heller) Ewan. (*Gilia virgata* var. *floribunda* Gray; *Gilia pluriflora* Heller; *Hugelia Brauntonii* (Jepson and Mason) Jepson.) Steep talus or rocky chaparral areas, east side of the range.

*GILIA ACHILLEAEFOLIA* Benth. Openly wooded slopes, occasional across range.

*GILIA TRICOLOR* Benth. Frequent vernal annual on open hillsides or valley flats across range.



GILIA SP. Grassy slopes, west side and interior of range. Smith Creek, *H. K. Sharsmith 614, 1017* (UC); Packard Ridge, *Mason 7203, 7204* (UC). This is a species of infrequent occurrence in the Coast Ranges, for which only a manuscript name is available. It is related to *G. tricolor* and *G. multicaulis*, but is probably closer to the latter.

GILIA MULTICAULIS Benth. (*G. peduncularis* Eastw.) Frequent on open hillsides across range. Although *Gilia peduncularis* is often given specific rank, it is here treated as synonymous with *G. multicaulis*, for the Mount Hamilton Range material shows every intergradation between the cymosely clustered, loose glomerules of flowers in the inflorescence of typical *G. multicaulis*, and the pedicelled, solitary flowers in the open, cymose inflorescence of typical *G. peduncularis*.

GILIA MILLEFOLIATA Fisch. and Mey. Infrequent across range on open hillsides. Often intergrading with *G. multicaulis*, but appearing to be much more distinct than *G. peduncularis*.

GILIA GILIOIDES (Benth.) Greene. Frequent vernal annual on dry slopes across range.

LINANTHUS DICHOTOMUS (Benth.) Benth. (*Gilia dichotoma* Benth.) Occasional on open hillsides across range.

LINANTHUS PHARNACEOIDES (Benth.) Greene. (*L. liniflorus* (Benth.) Greene.) Occasional, west side of range.

LINANTHUS AMBIGUUS (Rattan) Greene. (*Gilia ambigua* Rattan; *Dactylophyllum ambiguum* Heller; type from Oak Hill, west base Mount Hamilton Range, Santa Clara County, Rattan.) Frequent on open hillsides or gravelly flats across range.

LINANTHUS PYGMAEUS (Brand) Howell. (*Gilia pusilla* and *Linanthus pusilla* of authors, non Greene.) Open slopes or gravelly flats, interior and east side of range.

LINANTHUS DENSIFLORUS (Benth.) Milliken. (*L. grandiflorus* Greene.) Open slopes, west side and interior of range near its western margin.

LINANTHUS ANDROSACEUS (Benth.) Greene. Common on open slopes across range.

LINANTHUS PARVIFLORUS (Benth.) Greene. (*Gilia lutea* Steud.) Frequent on open slopes, interior and east side of range.

LINANTHUS BICOLOR (Nutt.) Greene. (*Gilia bicolor* Brand.) Frequent on open slopes across range. This species and the preceding form a complex, the relationships of which are not clear.

LINANTHUS CILIATUS (Benth.) Greene. (*Gilia ciliata* Benth.) Occasional in grassland, interior and east side of range.

#### HYDROPHYLLACEAE

HYDROPHYLLUM OCCIDENTALE Gray. Occasional on brushy slopes, interior of range.

NEMOPHILA MENZIESII Hook. and Arn. (*N. insignis* Benth.) Occasional early spring annual on wooded slopes across range.

NEMOPHILA PEDUNCULATA Dougl. Occasional on wooded slopes, west side and interior of range.

NEMOPHILA SEPULTA Parish. (*N. pedunculata* var. *sepulta* Nels. and Macbr.) Occasional on openly wooded slopes, west side and interior of range. Questionably distinct from the preceding species.

NEMOPHILA HETEROPHYLLA Fisch. and Mey. var. *NEMORENSIS* (Eastw.) Jepson. Occasional, west side of range on grassy slopes. The variety doubtfully distinguishable from the species.

PHOLISTOMA MEMBRANACEA (Benth.) Constance. (*Ellisia membranacea* Benth., and var. *hastifolia* Brand.) Occasional in moist areas, east side and interior of range.

PHOLISTOMA AURITA (Lindl.) Lilja. (*Nemophila aurita* Lindl.) Shaded canyons, west and north margins of the range.

EUCRYPTA CHRYSANTHEMIFOLIA (Benth.) Greene. (*Ellisia chrysanthemifolia* Benth.) Shaded areas, west side and north margin of range.

PHACELIA CALIFORNICA Cham. var. *IMBRICATA* (Greene) Jepson. (*P. imbricata* Greene; *P. californica* Cham. var. *calycosa* (Gray) Dundas.) Occasional across range on rocky, dry slopes.

*PHACELIA STIMULANS* Eastw. Restricted to unstable talus or rocky slopes, Red Mountains, East edge San Antonio Valley, C. W. and H. K. Sharsmith 982 (UC); Colorado Creek, H. K. Sharsmith 3894 (UC); Arroyo del Puerto, H. K. Sharsmith 3786 (UC). A segregate of the *P. magellanica* complex, and like the latter species a complex entity. Specimens determined by J. T. Howell. In *P. magellanica* the corolla is tubular-campanulate to open-campanulate with the lobes suberect or distinctly spreading. In *P. stimulans* the corolla is tubular with lobes erect only at anthesis and curving inward thereafter so that the tips are approximate; in addition the sepals are widest at or above the middle, and the glandular hairs are usually numerous on stems, leaves, and sepals.

*PHACELIA TANACETIFOLIA* (Benth.) (*P. tanacetifolia* var. *pseudo-distans* Band, type from Red Mountains, Mount Hamilton Range, Elmer 4338). Across range on rocky slopes, but infrequent.

*PHACELIA BREWERI* Gray. Frequent on rocky ridges or loose shale slopes across range. This central Coast Range endemic species is very abundant in the Mount Hamilton Range in suitable habitats at elevations from 250 to 4000 feet.

*PHACELIA DISTANS* Benth. (*P. leptostachya* Greene; *P. distans* var. *australis* Brand.) Frequent across range on exposed hillsides.

*PHACELIA RAMOSISSIMA* Dougl. var. *SUFFRUTESCENS* Parry. Occasional on openly wooded slopes, west side and interior of the range.

*PHACELIA CILIATA* Benth. In dried-out vernal pools, east side of range.

*PHACELIA RATTANII* Gray. Occasional on shaded hillslopes or near streams, interior of range. Santa Isabella Creek, C. W. and H. K. Sharsmith 3732 (UC); San Antonio Creek, C. W. and H. K. Sharsmith 996 (UC). The Santa Cruz Mountains and Mount Hamilton Range (the above specimens mark the first record from this latter area) represent the known southern distribution of this North Coast Range and southern Oregon species.

*PHACELIA DOUGLASHI* (Benth.) Torr. var. *PETROPHILA* Jepson, type from Corral Hollow, Mount Hamilton Range, Jepson 9583. Corral Hollow.

*PHACELIA DIVARICATA* (Benth.) Gray. Occasional on open rocky or grassy slopes, interior of range.

*PHACELIA PHACELIOIDES* (Benth.) Brand. (*P. circinatifolia* Gray.) Infrequent on rocky slopes, interior of range. Mount Hamilton, H. K. Sharsmith 3724 (UC); Sugarloaf Mountain, H. K. Sharsmith 3640 (UC); Sweetwater Creek, C. W. and H. K. Sharsmith 3080 (UC). For many years this species was known only from the original Douglas collections ("California"—exact locality uncertain). T. Brandegee cited it (Zoe 4: 115, 1893) from Mount Hamilton (W. W. Price in 1890) as *P. circinatifolia*, but the Price specimen cannot now be located. In more recent years several collections were made from Mount Diablo. The collections, therefore, amplify considerably the available material of this species. It occurs as low as 2100 feet both on Mount Diablo and in the Mount Hamilton Range.

*PHACELIA FREMONTII* Torr. Corral Hollow, Hoover 3032 (UC). A typically desert species which reaches its northern limit in the Mount Hamilton Range.

*LEMMONIA CALIFORNICA* Gray. In chaparral. Arroyo Mocho, H. K. Sharsmith 3511 (CA); west slope Red Mountains, H. K. Sharsmith 3619 (UC). The previously recorded distribution of *L. californica* is as follows: Mohave Desert, to Tehachapi Mountains and southern Sierra Nevada, south to northern Lower California; Lake County of North Coast Ranges. The above collections are thus the first to be recorded from the South Coast Ranges, and they render much less discontinuous the known distribution of this essentially desert species.

*EMMENANTHE PENDULIFLORA* Benth. Occasional on hillsides or in sandy flood beds of streams, interior and east side of range.

*EMMENANTHE PENDULIFLORA* var. *ROSEA* Brand. Steep serpentine talus, Red Mountains. Arroyo del Puerto, Mason in 1935 (UC), C. W. and H. K. Sharsmith 3145 (UC); Adobe Creek, H. K. Sharsmith 3781 (UC); Red Mountain, Elmer 4877 (UC). The type locality of this little known variety is Mount Pinos, Tehachapi Mountains, Ventura County, California, and its known distribution is limited to Mount Pinos and to the South Coast Ranges as far north as the Red Mountains of the Mount

Hamilton Range. The only character used by Brand (Pflanzr. 4(251):134. 1913) to distinguish the variety *rosea* is the pink flowers as compared to the yellow flowers of the species, and subsequent workers have usually reduced the variety to synonymy under the species. In the Red Mountains, however, the variety *rosea*, in addition to the pink flowers, shows the following points of differentiation from the species: leaves fern-like, more finely and regularly dissected than in the species, sometimes pinnate or with but a narrow strip of leaf blade on either side of the midrib between the widely spaced lobes; stems reddish (green in the species); paniculate cymes longer, flowers more widely spaced on the rachis than in the species. There seems to be some intergradation with the species in all these characters, but on the basis of the above the variety *rosea* appears to be well marked and fully worthy of recognition.

There is a lack of geographical segregation between species and variety, but in the Mount Hamilton Range there is indication of an ecological separation. Although the species occurs from one margin of the range to the other in its typical phase, it is absent from the Red Mountains where the variety is found. The Red Mountains consist of decomposed serpentine rock, and it is possible that the variety *rosea* may be limited throughout its range to areas of serpentine rock.

ERIODICTYON CALIFORNICUM (Hook. and Arn.) Greene. Occasional chaparral constituent, interior and east side of range.

#### BORAGINACEAE

HELIOTROPIMUM CURASSAVICUM L. var. OCULATUM (Heller) Johnston. (*H. curassavicum* L. in part.) Flood beds of streams, interior and east side of range; infrequent.

CYNOGLOSSUM GRANDE Dougl. Wooded slopes, west side and interior of range.

PECTOCARYA LINEARIS DC. var. FEROCULA Johnston. Corral Hollow.

PECTOCARYA PUSILLA (DC.) Gray. Wooded areas, interior of range.

PECTOCARYA PENICILLATA (Hook. and Arn.) DC. Hillslopes, east side of range.

PECTOCARYA SETOSA Gray. Corral Hollow, Hoover 3042 (UC). A typically desert and Great Basin species, not before found as far north as the Mount Hamilton Range in the inner South Coast Ranges.

AMSINCKIA GRANDIFLORA Kleeb. (*A. spectabilis* of some authors, non Fisch. and Mey.) Corral Hollow, Hoover 2866, 3021, 3357 (UC). A seldom collected, distinctive and highly restricted species, known only from Antioch, Contra Costa County, and the northern end of the Mount Hamilton Range in the vicinity of Corral Hollow.

AMSINCKIA VERNICOSA Hook. and Arn. Corral Hollow, Hospital Canyon. A typically desert species of infrequent occurrence in the South Coast Ranges to Corral Hollow.

AMSINCKIA TESSELATA Gray. Occasional, east side of range.

AMSINCKIA PARVIFLORA Heller (Muhl. 2:313. 1907), type from Alum Rock Park, Heller 8470. Occasional, west side and interior of range.

AMSINCKIA INTERMEDIA Fisch. and Mey. (*A. spectabilis* and *A. Douglasiana* of authors.) Occasional across range on grassy slopes.

AMSINCKIA EASTWOODAE Macbride. (*A. Douglasiana* var. *Eastwoodae* Jepson.) Arroyo del Puerto.

CRYPTANTHE FLACCIDA (Dougl.) Greene. Frequent on dry, open hillsides across range.

CRYPTANTHE HISPIDISSIMA Greene. Arroyo del Puerto, C. W. and H. K. Sharsmith 1537a (UC), immature.

CRYPTANTHE NEVADENSIS Nels. and Kenn. var. RIGIDA Johnston. Open hillsides or grassy flats, east margin of range.

CRYPTANTHE TORREYANA Greene var. PUMILA (Heller) Johnston. (*C. pumila* Heller.) Open hills, chaparral slopes, or valley flats across range.

CRYPTANTHE SPARSIFLORA Greene. Arroyo del Puerto.

CRYPTANTHE NEMAELADA Greene. Arroyo del Puerto.

CRYPTANTHE CLEVELANDII Greene. Hospital Canyon.

CRYPTANTHE COROLLATA (Johnston) Johnston. (*C. decipiens* var. *corollata* Johnston.) Arroyo del Puerto.

PLAGIOBOTHRYUS BRACTEATUS (Howell) Johnston. (*Allocarya bracteata* Howell;

*A. californica* of authors.) Frequent at stream margins or edges of vernal pools, west side and interior of range.

*PLAGIOBOTHRYS ACANTHOCARPUS* (Piper) Johnston. (*Allocarya acanthocarpa* Piper; *Plagiobothrys Greenei* (Gray) Johnston; *Echinoglocin acanthocarpa* Brand.) Open grassland, east margin of range.

*PLAGIOBOTHRYS TENELLUS* (Nutt.) Gray. Frequent on open hillsides across range.

*PLAGIOBOTHRYS MYOSOTOIDES* (Lehm.) Brand. Chaparral ridge between Santa Isabella Valley and Arroyo Bayo, C. W. and H. K. Sharsmith 1893 (UC). A South American species, of which this is the first North American collection; cited by I. M. Johnston (Journ. Arn. Arb. 20:381. 1939).

*PLAGIOBOTHRYS CANESCENS* Benth. Grassy slopes, east side of range and in Arroyo Mocho.

*PLAGIOBOTHRYS ARIZONICUS* (Gray) Greene. Corral Hollow. A typically desert borage for which only isolated stations are known in the inner South Coast Ranges.

*PLAGIOBOTHRYS NOTHOFULVUS* Gray. Frequent on open hillslopes across range.

*PLAGIOBOTHRYS INFECTIVUS* Johnston, Journ. Arn. Arb. 20:380. 1939, type from lower Hospital Canyon, Mount Hamilton Range, Hoover 3067 (G), isotype (UC!); Corral Hollow, Hoover 1744 (UC).

#### VERBENACEAE

*VERBENA PROSTRATA* R. Br. Infrequent in dry ground of valley flats, interior of range.

#### LABIATAE

*TRICHOSTEMA LANCEOLATUM* Benth. Frequent on dry, open slopes, west side and interior of range.

*SCUTELLARIA SIPHOCAMPYLOIDES* Vatke. (*S. angustifolia* Pursh var. *canescens* Gray.) Occasional in rocky areas at stream margins, or flood beds of streams, interior of range.

*SCUTELLARIA TUBEROSA* Benth. Open hillsides or chaparral, interior and east side of range, infrequent.

\**MARRUBIUM VULGARE* L. Common only on neglected agricultural lands, west side of range near base.

*SALVIA CARDUACEA* Benth. Corral Hollow, Brewer 1210 (UC), Carter 787 (UC). Typically a desert species of southern California.

*SALVIA COLUMBARIAE* Benth. Dry, often rocky hillsides, interior and east side of range, abundant in scattered colonies.

*SALVIA MELLIFERA* Greene. East side of range as an occasional chaparral constituent, or sometimes abundant with *Artemisia californica*.

*ACANTHOMINA LANCEOLATA* Curran. Type from Calaveras Valley, Mount Hamilton Range, June 1878, E. Brooks; this area is now inundated by the Calaveras Reservoir. Rocky slopes, usually of loose shale across range, but mainly restricted to interior and east side. Mount Hamilton, Greene in 1891 (UC), C. W. and H. K. Sharsmith 1233 (UC); Santa Isabella Valley, C. W. and H. K. Sharsmith 1934 (UC); San Antonio Creek, C. W. and H. K. Sharsmith 3194 (UC); Arroyo del Puerto, C. W. and H. K. Sharsmith 3112 (UC), Hoover 2628 (UC); Soda Springs Canyon, Pine Ridge, Dudley 4151 (UC).

The genus *Acanthomina* consists of three species, *A. ilicifolia* Gray, *A. lanceolata* Curran, and *A. obovata* Jepson, all restricted to California. In order to determine the position of *A. lanceolata*, a careful morphological study of the three species was made. They show close relationship and are similar in habit, but there is good evidence of specific differentiation, and intergradation is relatively minor or lacking.

Differences in bracts and leaves have been used to distinguish the three species, but these characters are not satisfactory for this purpose. The shape of the bracts is nearly uniform in all three species, and although the marginal spines vary somewhat in number they are most typically seven or nine throughout. The leaves tend to be very similar in all three species. Specific differences of a more reliable nature are tabulated below:

|         | <i>A. lanceolata</i>   | <i>A. obovata</i>   | <i>A. ilicifolia</i>   |
|---------|--|---|--|
| Herbage | Pilose puberulent, somewhat glandular.   | Canescent or subglabrous.   | Subglabrous or glabrous.   |
| Calyx   | Aristate teeth of upper lip 5-7 mm. long.  | Aristate teeth of upper lip 1-3 mm. long.   | Aristate teeth of upper lip 1-1.5 mm. long.  |
| Corolla | Upper lip 2-lobed at apex, 5 mm. long; lower lip 5-6 mm. long, median lobe linear. | Upper lip entire, 3-4 mm. long; lower lip 5-6 mm. long, median lobe of lower lip not elongate, lateral lobes broad. | Upper lip entire, 3-4 mm. long; lower lip 5-6 mm. long; median lobe not elongate, lateral lobes broad. |
| Anthers | Glabrous or sparsely hairy.  | Woolly.   | Glabrous.  |
| Style   | Sparsely hairy.  | Glabrous.   | Glabrous.  |

Of these differentiating characteristics, one that is not found in any of the species descriptions is that of the calyx teeth. On the basis of this and other diagnostic features, the following key to the genus is presented:

- Aristate teeth of upper calyx lip 5-7 mm. long; anthers glabrous or sparsely hairy; style sparsely hairy ..... *A. lanceolata*  
 Aristate teeth of upper calyx lip 1-3 mm. long; style glabrous.  
 Anthers woolly ..... *A. obovata*  
 Anthers glabrous ..... *A. ilicifolia*

*Acanthomintha lanceolata* is found in the Mount Hamilton Range and south in the San Carlos Range to the area where Gavilan and San Carlos ranges join (southern border of San Benito County and northern edge of Monterey County). At its northern boundary, *A. obovata* overlaps the southern boundary of *A. lanceolata* and extends south in the South Coast Ranges to the Mount Pinos region of Ventura County. *Acanthomintha ilicifolia* is usually considered as limited to the seacoast mesas of western San Diego County, but several collections have been made from San Mateo County in the outer South Coast Ranges which appear definitely to belong to *A. ilicifolia*, thus giving this species a very discontinuous distribution.

T. S. Brandegee (Zoe 4:156. 1893) suggests that *Acanthomintha lanceolata* merges with *A. ilicifolia* in the southern San Carlos Range-Gavilan Range area. At least in part, Brandegee was apparently dealing with material of the then undescribed *A. obovata*. With the additional knowledge now available of the distribution and morphology of these species, his arguments do not seem tenable.

*Acanthomintha obovata* and *A. ilicifolia* have in common corolla shape and size and a glabrous style, and they may intergrade as to the subglabrous condition and the length of the aristate upper calyx teeth. *Acanthomintha lanceolata* is the most strongly differentiated species, being marked not only by differences in corolla shape and size, and sparsely hairy style, but as well by the pilose, somewhat glandular pubescence, and the very long aristate upper calyx teeth. *Acanthomintha ilicifolia* appears to be the most primitive species, and *A. lanceolata* the most advanced. Analysis of morphology along with geographic distribution suggests that *A. ilicifolia* may once have occupied more or less continuously the coastal region of California between San Diego County and central California. *Acanthomintha obovata* and *A. lanceolata* appear to have arisen directly or indirectly as offshoots of this species, replacing it in much of its original range, so that *A. ilicifolia* is now restricted to the northern and southern extremities of the area occupied by the genus as a whole.

POGOCYNE SERPYLLOIDES (Torr.) Gray. Occasional in chaparral, interior of range.  
 SATUREJA DOUGLASHI (Benth.) Briq. (*Micromeria Chamissonis* (Benth.) Greene.)

Wooded areas, west side of range, infrequent. Typically an outer Coast Range species; seldom collected from inner Coast Ranges.

*STACHYS PYCNANTHA* Benth. Near springs, Mount Hamilton.

*STACHYS AJUGOIDES* Benth. Moist depressions, Santa Isabella Valley.

*STACHYS RIGIDA* Nutt. subsp. *QUERCETORUM* (Heller) Epling. (*S. quercetorum* Heller; *S. bullata* of authors, non Benth.) Occasional on wooded slopes, west side and interior of range.

\**LAMIUM AMPLEXICAULE* L. Edge of stream, Arroyo Bayo.

*MONARDELLA VILLOSA* Benth. subsp. *SUBSERRATA* (Greene) Epling. (*M. villosa* var. *lomentosa* Jepson.) Frequent on rocky slopes across range.

*MONARDELLA DOUGLASII* Benth. Dry, rocky slopes, occasional across range.

*MONARDELLA BREWERI* Gray, type from Corral Hollow, Mount Hamilton Range, Brewer 1263, June 3, 1892, isotype UC! The type locality represents the northern limit of distribution for this species; it extends south in the inner South Coast Ranges to the Mohave Desert.

#### SOLANACEAE

*DATURA METELOIDES* DC. Flood bed, Arroyo del Puerto.

*PETUNIA PARVIFLORA* Juss. Flood bed Santa Isabella Creek.

\**NICOTIANA GLAUCA* Graham. Canyon bottoms, east side of range.

*NICOTIANA ATTENUATA* (Torr.) Wats. Occasional in valleys or flood beds of streams, interior of range.

*SOLANUM UMBELLIFERUM* Esch. Occasional across range on openly wooded slopes.

#### SCROPHULARIACEAE

\**VERBASCUM THAPSUS* L. Arroyo del Vallé.

*ANTIRRHINUM GLANDULOSUM* Lindl. Infrequent in chaparral across range.

*ANTIRRHINUM VEXILLO-CALYCATUM* Kell. var. *TYPICUM* Munz. (*A. vagans* Gray; *A. vagans* var. *rimorum* Jepson, type from Morrison Canyon, Mount Hamilton Range, Jepson.) Occasional on rocky slopes or in chaparral across range.

*ANTIRRHINUM VEXILLO-CALYCATUM* Kell. var. *BREWERI* (Gray) Munz. (*A. vagans* var. *Breweri* Jepson.) North side Arroyo Bayo, Mason 11699 (UC). Not reported hitherto from the South Coast Ranges. Although stems of the plants from the above collection are not "quite glandular pubescent throughout" as described by Munz, the plants otherwise match description and specimens of variety *Breweri*, and are sharply distinguished from the preceding variety *typicum*.

*LINARIA TEXANA* Scheele. (*L. canadensis* Dum.; *L. canadensis* var. *texana* Pennell.) Chaparral, Santa Isabella Valley.

*COLLINSIA HETEROPHYLLA* Graham. (*C. bicolor* Benth., non Raf.) Frequent on wooded slopes across range. In the Mount Hamilton Range material the corolla varies widely and the calyces may be villous or glabrous within the same colony or between separate colonies. The length of the filament appendages in separating this and the other species of *Collinsia* as used by Newsom (Bot. Gaz. 87:260-301, 1929) is an obscure basis for differentiation, and in the Mount Hamilton Range material is not reliable.

*COLLINSIA BARTSIAEFOLIA* Benth. Seeboy Ridge. Separated from *C. heterophylla* with considerable difficulty; *C. bartsiaefolia* has smaller flowers, narrower bases to the crenate leaves, and no pubescent appendages at the bases of the upper filaments.

*COLLINSIA SPARSIFLORA* Fisch. and Mey. var. *SOLITARIA* (Kellogg) Newsom. Frequent on wooded slopes across range.

*TONELLA TENELLA* (Benth.) Heller. Wooded slopes, Mount Hamilton.

*SCROPHULARIA CALIFORNICA* Cham. Occasional on wooded slopes, west side of range.

*PENSTEMON CORYMBOSUS* Benth. Rocky outcrops, west side of range.

*PENSTEMON BREVIFLORUS* Lindl. subsp. *TYPICUS* Keck. Occasional on chaparral slopes across range.

*PENSTEMON HETEROPHYLLUS* Lindl. subsp. *TYPICUS* Keck. Occasional on chaparral slopes across range.

*PENSTEMON HETEROPHYLLUS* Lindl. subsp. *PURDYI* Keck, type from Mount Ham-



ilton, April, 1903, *Elmer* 4832. (*P. azureus* of authors, non Benth.) Open, rocky hillsides, west side of range.

*PEDICULARIS DENSIFLORA* Benth. Wooded areas, west side and interior of range, infrequent.

*MIMULUS AURANTIACUS* Curt. (*Diplacus aurantiacus* (Curt.) Jepson; *Diplacus glutinosus* Nutt.) Occasional on rocky slopes across range.

*MIMULUS ANDROSACEUS* Curran. (*M. Palmeri* Gray var. *androsaceus* (Curran) Gray.) Infrequent in chaparral, interior of range. Arroyo Bayo, *H. K. Sharsmith* 1703 (UC); Red Mountains, *H. K. Sharsmith* 3617 (UC). These two collections represent a long extension of known range for *M. androsaceus*, as this little known species has been considered to be restricted to the Tehachapi Mountains. There is a previous record of it from the South Coast Ranges, however, which has passed unnoticed. *Elmer* (Bot. Gaz. 41:324, 1906), under *Eunanus androsaceus* Curran, makes the following comments: "From the middle western part of the state it is only known at Ben Lomond, Santa Cruz County, where fruiting specimens were collected by Mrs. K. Brandegee in April, 1890. In July, 1903, the writer found excellent flowering specimens in the same locality, which were distributed under 4519. It is evidently rare and prefers hot and dry gravelly soil of the chaparral. . . ." These two specimens cannot now be located.

*MIMULUS ANDROSACEUS* is closely allied to *M. Palmeri*, but is distinguished by the spreading, longer pedicels, the glabrous, truncate and mucronate calyx teeth, the smaller corolla with equal, entire lobes, and the glabrous anthers.

*MIMULUS BOLANDERI* Gray var. *BRACHYDONTUS* Grant (as *Eunanus Bolanderi* Greene, *Erythra* 1:95. 1893.) Rocky hillsides or in chaparral, occasional across range.

*MIMULUS FLORIBUNDUS* Dougl. Moist flood bed Santa Isabella Creek.

*MIMULUS CARDINALIS* Dougl. Santa Isabella Creek.

*MIMULUS NASUTUS* Greene. (*M. guttatus* DC. var. *nasutus* Jepson; *M. guttatus* of authors in part.) Frequent in moist areas across range.

*MIMETANTHE PILOSA* (Benth.) Greene. Occasional in moist areas, interior of range.

*VERONICA AMERICANA* (Raf.) Schweinitz. Springs, north side Mount Hamilton.

*VERONICA PEREGRINA* L. subsp. *XALAPENSIS* (HBK) Pennell. Occasional in moist areas, interior of range.

*CASTILLEJA ROSEANA* Eastw. Rocky ridge, Copernicus Peak, *H. K. Sharsmith* 920 (UC), *Morrison and Carter* 3100 (UC). This species was based on the three existing specimens from the San Carlos Range (Eastwood, Leaf. West. Bot. 2:104. 1938). The type was collected between San Lucas and Priest Valley, Monterey County (San Carlos Range), *Eastwood and Howell* 2460 (CA, isotype CA!). The Mount Hamilton locality extends the known range of the species as follows: San Carlos Range and Mount Hamilton Range of inner South Coast Ranges.

Close morphological relationship is obvious between *Castilleja Roseana* and *C. latifolia* Hook. and Arn., the latter a species of the immediate seacoast between Monterey and Mendocino counties. In order to determine if *C. Roseana* justified specific distinction from *C. latifolia*, fresh and herbarium specimens of both species were studied.

*Castilleja latifolia* shows a very considerable range of variation: the herbage varies from slightly glandular to viscid (in the variety *Wightii* Ziehle); the leaves range from 0.5 cm. long, entire and oval to 5 cm. long, ovate-lanceolate, and with one or two pairs of lateral lobes; the bracts vary from yellow to scarlet or crimson, and from 1 cm. long, entire and oval to 2.5 cm. long, triangular-obovate, and with one or two pairs of weakly or well developed lobes, the central segment rounded to erose-truncate at apex; the calyx is 12-30 mm. long, with sagittal incisions 6-15 mm. deep, the lateral lobes scarcely evident to well developed; the corolla is 15-30 mm. long, the galea 8-15 mm. long, with the lower lip either included or somewhat exserted.

*Castilleja Roseana* could fit into the extremes of variation represented above for *C. latifolia*, except that the plants are very viscid glandular throughout (even much more so than in *C. latifolia* var. *Wightii*), and the leaves are strongly undulant margined ("attenuate and crisped" according to the original description). The leaves are striking even in the herbarium mounts, for the leaf margins appear erose when flattened, although this is not so evident when the plants are fully mature. Due to the usual presence of a

pair of divaricate lobes, the bracts are typically broader than long in *C. Roseana*, but this same shape is found occasionally among the multishaped bracts of *C. latifolia*. Certain minor differences were noted in the fresh flowers of *C. Roseana* as compared to the fresh flowers of *C. latifolia*: the galea was diffused with red throughout and the style pink in *C. Roseana*, while the galea was red only along the margins and the style green in *C. latifolia*. Whether or not these distinctions hold throughout the range of *C. latifolia* cannot be determined accurately from herbarium material, as this species often loses color in the pressed plants.

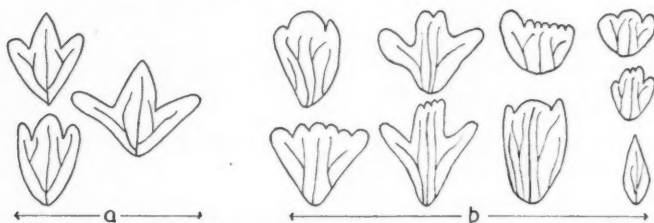


Fig. 10. Variations in bracts. a. *Castilleja Roseana*,  $\times \frac{2}{3}$ . b. *C. latifolia*,  $\times \frac{2}{3}$ .

From the above, it may seem that the morphological bases for distinguishing *C. Roseana* from *C. latifolia* are meager, but *C. Roseana* is relatively constant in its character and there is no significant variation between San Carlos Range and Mount Hamilton material of this species. When geographical distinction is added to morphological, the specific recognition of *C. Roseana* seems justified. Geographically, and ecologically as well, the inner Coast Range *C. Roseana* is strongly isolated from the strictly maritime *C. latifolia* which occurs only along a very narrow strip of seacoast.

*CASTILLEJA FOLIOLOSA* Hook. and Arn. Frequent on dry, open hills across range.

*CASTILLEJA DOUGLASSII* Benth. (*C. parviflora* Bong. var. *Douglasii* Jepson.) Occasional across range on wooded or grassy slopes.

*CASTILLEJA AFFINIS* Hook. and Arn. Occasional on openly wooded slopes across range. *H. K. Sharsmith 1979* (UC) from Seeboy Ridge has light salmon pink bracts, and is dubiously referred to this species. Much intergradation occurs between *C. affinis* and *C. Douglasii*, and their specific distinction is questioned.

*ORTHOCARPUS PUSILLUS* Benth. var. *TYPICUS* Keck. Occasional on openly wooded slopes across range.

*ORTHOCARPUS ERIANTHUS* Benth. var. *TYPICUS* Keck. Occasional; openly wooded slopes across range.

*ORTHOCARPUS ERIANTHUS* Benth. var. *MICRANTHUS* (Gray) Jepson. Grassland, Arroyo del Puerto.

*ORTHOCARPUS ATTENUATUS* Gray. Occasional in grassland, interior and east side of range.

*ORTHOCARPUS DENSIFLORUS* Benth. var. *TYPICUS* Keck. Occasional on openly wooded slopes, west side and interior of range.

*ORTHOCARPUS PURPURASCENS* Benth. var. *TYPICUS* Keck. Frequent vernal annual in valleys or on grassy slopes across range.

*CORDYLANTHUS RIGIDUS* (Benth.) Jepson var. *BREVIBRACTEATUS* (Gray) Jepson. (*Adenostegia rigida* var. *brevibracteata* Greene.) Occasional autumnal species on openly wooded slopes, interior and east side of range.

#### OROBANCHACEAE

*OROBANCHE UNIFLORA* L. var. *SEDI* (Suksd.) Achey. Infrequent on rocky, wooded slopes, interior and east side of range.

*OROBANCHE FASCICULATA* Nutt. (*Aphyllon fasciculatum* Gray.) Parasitic on *Eriogonum* spp., *Artemisia* spp., etc., occasional in interior and east side of range.

## PLANTAGINACEAE

\**PLANTAGO MAJOR* L. Moist sand, Santa Isabella Creek.

*PLANTAGO HOOKERIANA* Fisch. and Mey. var. *CALIFORNICA* (Greene) Poe. (*P. erecta* Morris.) Frequent vernal annual in grassland across range.

## RUBIACEAE

*GALIUM APARINE* L. Wooded hillsides, west side and interior of range.

*GALIUM ANDREWSII* Gray. Rocky outcrop, Santa Isabella Creek.

*GALIUM NUTTALLI* Gray. Wooded slopes, infrequent across range.

## CAPRIFOLIACEAE

*SAMBUCUS COERULEA* Raf. (*S. glauca* Nutt.) Occasional in canyons, west side and interior of range.

*SYMPHORICARPUS ALBUS* (L.) Blake. Common on west side of range, forming thickets on north-facing slopes.

*SYMPHORICARPOS MOLLIS* Nutt. (*S. albus* var. *mollis* (Nutt.) Keck.) Low compact shrub in wooded slopes, interior of range.

*LONICERA JOHNSTONI* (Keck) McMiinn. (*L. subspicata* var. *Johnstonii* Keck; *L. subspicata* of authors in part.) Frequent on brushy slopes across range. Predominately of southern California, although found in the inner South Coast Ranges to Mount Diablo.

*LONICERA INTERRUPTA* Benth. Occasional across range on brushy slopes. Some intergradation occurs in the Mount Hamilton Range between the mainly southern *L. Johnstoni* and the more northern *L. interrupta* where the two species overlap.

*LONICERA HISPIDULA* Dougl. (*L. hispidula* var. *californica* Greene; *L. hispidula* var. *vacillans* Gray.) Mount Hamilton; wooded areas.

## VALERIANACEAE

*PLECTRITIS SAMOLIFOLIA* (DC.) Hoeck. Occasional in moist areas, interior of range.

*PLECTRITIS MACROCERA* Torr. and Gray. Frequent vernal annual on wooded slopes, west side and interior of range.

*PLECTRITIS MAGNA* (Greene) Suksd. Occasional in grassy areas across range.

*PLECTRITIS CILIOSA* (Greene) Jepson. Frequent vernal annual on wooded slopes across range.

*ALIGERA RUBENS* Suksd. Wooded hills, Arroyo Bayo.

*ALIGERA COLLINA* (Heller) Suksd. (*Plectritis collina* Heller (Muhl. 2:329. 1907), type from western slope Copernicus Peak, Mount Hamilton Range, Heller 8609). Isotype WSC! Apparently a localized species; recollected on Mount Hamilton in 1938 by Dyal, but her specimen not seen by the writer.

## DIPSACACEAE

\**DIPSACUS FULLONUM* L. Springs, north side Mount Hamilton.

## CUCURBITACEAE

*ECHINOCYSTIS FABACEA* Naud. (*Micrampelis fabacea* Greene.) Occasional in wooded areas across range.

## CAMPANULACEAE

*CAMPANULA EXIGUA* Rattan. In isolated colonies across range, mainly on unstable talus of chaparral belt. *Campanula exigua* is restricted to Mount Diablo, Mount Hamilton Range, and San Carlos Range, all of the inner South Coast Ranges. The closely related species, *C. angustiflora* Eastw., is restricted to Mount Tamalpais, Cobb Mountain, Howell Mountain, and Mount St. Helena of the North Coast Ranges, with a recently described variety, *C. angustiflora* var. *exilis* Howell (Leaflet. West. Bot. 2:102. 1938) occurring in the Pinnacles of San Benito County.

*HETEROCODON RARIFLORUM* Nutt. Moist areas, interior of range.

*GITHOPSIS SPECULARIOIDES* Nutt. Occasional in rocky areas, west side and interior of range.

## LOBELIACEAE

NEMACLADUS MONTANUS Greene. (*Nemacladus rigidus* Curran var. *montanus* (Greene) Munz.) Unstable talus, Red Mountains.

NEMACLADUS RAMOSISSIMUM Nutt. Infrequent on rocky slopes, interior and east side of range. Possibly one of the varietal forms of the species.

## COMPOSITAE

MICROSERIS ACUMINATA Greene. (*M. Douglasii* and *M. Bigelovii* of authors.) Adobe Valley, H. K. Sharsmith 3558 (UC). Known from the North Coast Ranges, Napa County to Humboldt and Tehama counties, and from the Sierra Nevada foothills in Eldorado County. Many of the collections of *M. acuminata* are found in herbaria under *M. Douglasii* and *M. Bigelovii*. The latter occurs in the South Coast Ranges as well as northward, and it is probable that many of the *M. Bigelovii* South Coast Range specimens are actually *M. acuminata*. Among a group of species wherein the lines of differentiation are very difficult to draw, definite conclusions cannot be offered without detailed study.

MICROSERIS TENELLA (Gray) Sch. Bip. var. APHANTOCARPHA (Gray) Black. (*M. elegans* Greene.) Frequent in grassy areas, interior and east side of range.

MICROSERIS DOUGLASII (DC.) Sch. Bip. Frequent on grassy slopes across range.

MICROSERIS LINEARIFOLIA (DC.) Sch. Bip. (*Calais linearifolia* DC.; *Uropappus linearifolius* Nutt.) Common on open slopes across the range.

MICROSERIS LINDLEYI (DC.) Gray. (*Uropappus Lindleyi* DC.) Arroyo Mocho. Much less frequent than preceding species, but covering the same general habitats and area.

MICROSERIS SYLVATICA (Benth.) Sch. Bip. (*Scorzonella sylvatica* Benth.) Occasional on open slopes, interior and east side of range.

RAFINESQUIA CALIFORNICA Nutt. (*Nemeseris californica* Greene.) Wooded hillsides across range.

\*HYPOCHOERIS GLABRA L. Mount Hamilton.

STEPHANOMERIA VIRGATA Benth. (*Ptiloria canescens* Greene.) Dry canyon slopes, occasional across range.

STEPHANOMERIA EXIGUA Nutt. var. CORONARIA (Greene) Jepson. Dry hillsides, interior of range; infrequent.

\*LACTUCA SALIGNA L. Adobe Creek, Red Mountains.

\*Sonchus asper L. Infrequent, moist areas, interior of the range.

MALCOTHRIX COULTERI Harv. and Gray. Infrequent on dry, grassy slopes, east margin of range. Mainly desert and cismontane, reaching its northern outpost at Antioch, Contra Costa County.

MALCOTHRIX CLEVELANDII Gray. Occasional in chaparral, interior of range.

MALCOTHRIX FLOCCIFERA (DC.) Blake. (*M. obtusa* Benth.) Frequent on serpentine talus, Red Mountains and east slope of Mount Day Ridge, occasional on non-serpentine areas, interior of range.

AGOSERIS GRANDIFLORA (Nutt.) Greene. Occasional on rocky, wooded slopes, west side and interior of range.

AGOSERIS HETEROPHYLLA (Nutt.) Greene var. CALIFORNICA (Nutt.) Jepson. Occasional to frequent on grassy slopes or valley flats, interior of range.

AGOSERIS HETEROPHYLLA var. KYMAPLEURA Greene. Frequent in grasslands across range.

AGOSERIS PLEBEIA Greene. Wooded slopes, west side and interior of range.

HIERACIUM ALBIFLORUM Hook. Rocky slope, Mount Hamilton.

CREPIS OCCIDENTALIS Nutt. subsp. PUMILA (Rydb.) Bab. and Stebbins. (*C. occidentalis* of authors, non Nutt.) Mount Hamilton, Elmer 4872 (UC); Colorado Creek, H. K. Sharsmith 3185 (UC). "Mount Hamilton, Brewer 1304" according to Coville, Contrib. U. S. Nat. Herb. 3:561. 1896. These Mount Hamilton Range localities are the only South Coast Range areas known for this subspecies, which is described as apomict *hamiltonensis* by Babcock and Stebbins (Carn. Inst. Wash. Publ. 504:128, 132. 1938).

CREPIS MONTICOLA Cov. Wooded area, summit of Seeboy Ridge, *H. K. Sharsmith* 3059 (UC). Typically of North Coast Ranges, occurring south of Lake County only in Mount Hamilton Range, the Mount Hamilton specimens being designated by Babcock and Stebbins (*op. cit.*) as *apomict australis*.

GUTIERREZIA CALIFORNICA (DC.) Torr. and Gray. Dry, rocky areas, interior and east side of range.

GRINDELIA CAMPORUM Greene var. DAVYI (Jepson) Steyermark. (*G. robusta* Nutt. var. *Davyi* Jepson.) Occasional in rocky areas, interior and east side of range.

GRINDELIA CAMPORUM Greene var. PARVIFLORA Steyermark. Occasional; dry slopes, interior and east side of range.

GRINDELIA RUBRICAULIS DC. Occasional on exposed slopes, west side and interior of range. Questionably distinct from *G. camporum* var. *interioris*.

STENOTOPSIS LINEARIFOLIUM (DC.) Rydb. (*Haplopappus linearifolius* DC.) Chaparral element, interior and east side of range.

ERICAMERIA ARBORESCENS (Gray) Greene. (*Haplopappus arborescens* (Gray) Hall.) Chaparral areas, interior of range.

EASTWOODIA ELEGANS Brandegee. Hillsides, east side of range. Restricted to the extreme eastern side of inner South Coast Ranges from Corral Hollow to Maricopa Hills in Kern County.

CHRYSOETHAMNUS NAUSEOSUS (Pallas) Brit. var. MOHAVENSIS (Greene) Hall. (*Bigelovia mohavensis* Greene; *C. mohavensis* Greene.) Summit rocks, Copernicus Peak, *H. K. Sharsmith* 1404, 1418 (UC); loose talus, Colorado Creek, Red Mountains, *H. K. Sharsmith* 3892 (UC). A well defined variety in a highly polymorphic species; typically of western borders of Mohave Desert, found infrequently northward in the inner South Coast Ranges to Mount Hamilton Range. Only two other stations are known in the South Coast Ranges, both in San Carlos Range. Greene first found it upon Mount Hamilton in 1893 (*Erythea* 1:89, 1893).

SOLIDAGO CALIFORNICA Nutt. Occasional in moist gullies across range.

CHRYSOOPSIS VILLOSA (Pursh.) Nutt. var. ECHIOIDES (Benth.) Gray. (*C. echioides* Benth.) Exposed, dry slopes, Mount Hamilton, *H. K. Sharsmith* 1354, 1411 (UC). Much variation occurs, and more than variety *echioides* may be represented in the collections cited, but this highly polymorphic genus has been only poorly studied.

CHRYSOOPSIS VILLOSA (Pursh.) Nutt. var. SESSILIFLORA (Nutt.) Gray. Grassland, western slopes of range.

CHRYSOOPSIS OREGANA (Nutt.) Gray var. SCABERRIMA Gray. Occasional in dry flood beds, interior of range.

PENTACHAETA EXILIS Gray. (*P. exilis* var. *aphanochaeta* Gray.) Occasional on grassy slopes across range.

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PENTACHAETA LAXA Elmer, Bot. Gaz. 41:318, 1906, is based upon a collection from Cedar Mountain, Mount Hamilton Range, May, 1903, *Elmer* 4437. According to Elmer, "This distinct species. . . . evidently very rare." Examination of the isotype of *P. laxa* (UC!) and analysis of the type description proves the species to be *Baeria microglossa* (Gray) Greene of the tribe *Helenieae*.

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LESSINGIA HOLOLEUCA Greene. (*L. leptoclada* var. *hololeuca* Jepson.) Grassy slopes, west side of range.

LESSINGIA GERMANORUM Cham. var. PARVULA (Greene) Howell. (*L. parvula* Greene; *L. tenuis* var. *Jaredii* Jepson.) Frequent chaparral associate in interior of range. A highly polymorphic species represented by ten variants, all of which show intergradation where they overlap. In general, however, the Mount Hamilton Range material represents the variety *parvula* (J. T. Howell, Univ. Calif. Publ. Bot. 16: 17, 1929).

LESSINGIA NEMAELADA Greene. (*L. ramulosa* var. *microcephala* Jepson.) Open chaparral, rocky slopes, Red Mountains. Arroyo del Puerto, *H. K. Sharsmith* 3789 (UC); San Antonio Valley, *H. K. Sharsmith* 3906 (UC). These collections represent

the species typical more nearly than the widespread var. *mendocino* (Greene) Howell or the little known var. *albiflora* (Eastw.) Howell.

*Lessingia nemaclada* variety *albiflora* (Eastw.) Howell was collected near San Antonio Valley by D. D. Keck. The collection was not seen by the writer.

*CORETHROGYNE FILAGINIFOLIA* (Hook. and Arn.) Nutt. var. *TYPICA* Canby. Frequent on dry, exposed slopes, west side of range, occasional in interior.

*ASTER MENZIESII* Lindl. Dry hillsides, Mount Hamilton.

*ERIGERON MISER* Gray. Rocky ridges, west side of range.

*ERIGERON PHILADELPHICUS* L. Moist areas, west side and interior of range.

*BACCHARIS PILULARIS* DC. var. *CONSANGUINEA* Wolf. Occasional, west side of range in shallow ravines.

*BACCHARIS DOUGLASII* DC. Occasional, moist areas, interior of range.

*BACCHARIS VIMINEA* DC. Occasional along stream margins, interior and east side of range. *H. K. Sharsmith 3767* (UC) from Arroyo del Puerto approaches the leaf characteristics of *B. Douglasii*, but has the floral characteristics and shrubby habit of *B. viminea*.

*MICROPUS CALIFORNICUS* Fisch. and Mey. Occasional on exposed hillsides across range.

*FILAGO CALIFORNICA* Nutt. Occasional on exposed hillsides across range.

*STYLOCLINE GNAPHALOIDES* Nutt. Open chaparral, interior of range.

*STYLOCLINE FILAGINEA* Gray. Occasional on brushy or chaparral slopes, interior and east side of range.

*PSILOCARPHUS TENELLUS* Nutt. Occasional in moist areas of valleys across range.

*EVAX SPARSIFLORA* (Gray) Jepson (probably var. *BREVIFOLIA* (Gray) Jepson.) Rocky areas, interior of range.

*GNAPHALIUM PALUSTRE* Nutt. Stream flood beds or margins of vernal pools, west side and interior of range.

*GNAPHALIUM CALIFORNICUM* DC. (*G. decurrens* Ives var. *californicum* (DC.) Gray.) Open hillsides, west side and interior of range. If *G. californicum* were to be considered as a variety of the Great Basin species known as *G. decurrens* Ives (intergradation does occur to some extent), a new combination would be necessary, for *G. decurrens* Ives, which preceded *G. californicum* as to date of publication, is a later homonym of *G. decurrens* L. Greene first recognized this (Ottawa Nat. 15:278. 1902) and published the new binomial *G. Macounii* Greene.

*GNAPHALIUM CHILENSE* Spreng. Occasional in flood beds, interior and east side of range.

*HELIANTHUS CALIFORNICUS* DC. Stream bed, Adobe Creek.

*BALSAMORHIZA MACROLEPIS* Sharp. (*B. Hookeri* of authors, non Nutt.) Occasional, rocky slopes, west side and interior of range.

*WYETHIA ANGUSTIFOLIA* (DC.) Nutt. Rocky slope, west side Mount Hamilton.

*WYETHIA HELENIODES* (DC.) Nutt. Scattered, isolated plants common on west side and interior of range.

*HELIANTHELLA CALIFORNICA* Gray. Rocky wooded or chaparral areas, west side and interior of range. It is questionable if *H. californica* of the central Coast Ranges is distinct from *H. castanea* Greene of Mount Diablo; both appear to lack satisfactory geographical separation and morphological distinctions.

*COREOPSIS HAMILTONII* (Elmer) H. K. Sharsmith, *Madroño* 4:214. 1938. (*Leptosyne hamiltonii* Elmer, Bot. Gaz. 41: 323. 1906, type from Mount Hamilton, April, 1900, Elmer 2328) Topotypes: Copernicus Peak, *H. K. Sharsmith 914*, 1839 (UC); Mount Hamilton, *Eastwood 11671* (CA). Other collections: Mount Hamilton-Livermore road, *Eastwood 12468* (CA); San Antonio Valley, *Wieser* (S); Arroyo Bayo, *H. K. Sharsmith 1709*, 3628, 3489 (UC). *Coreopsis hamiltonii* is known only from exposed, dry rocky slopes of the west summits and interior of Mount Hamilton Range.

*COREOPSIS CALLIOPSIDEA* (DC.) Gray. (*Leptosyne calliopsidea* Gray.) Abundant in isolated colonies, hillsides of east side and interior of range. A typically desert species, occasional in the inner South Coast Ranges to Corral Hollow of Mount Hamilton Range.

*COREOPSIS DOUGLASII* (DC.) Hall (as to name but not as to description). *Leptosyne Douglasii* DC.; *C. Stillmanii* var. *Jonesii* Sherff.) Dry, shale slopes, Arroyo Bayo,



*H. K. Sharsmith 3490, 3627, 3944, 3946* (UC). *Coreopsis Douglasii* occurs on dry rocky slopes of the inner South Coast Ranges from the Mount Hamilton Range to San Luis Obispo County. The relationships of this species to *C. californica* Nutt. of southern California are discussed in a separate publication of the writer (Madroño 4:209-231. 1938.)

*COREOPSIS STILLMANII* (Gray) Blake. (*Leptosyne Stillmanii* Gray.) In localized colonies on rocky, dry slopes, interior and east side of range.

*HEMIZONIA PUNGENS* (Hook. and Arn.) Torr. and Gray subsp. *INTERIOR* Keck. (*Centromadia pungens* Greene.) Chaparral slopes, east side of range.

*HEMIZONIA FITCHII* Gray. (*Centromadia Fitchii* Greene.) Dry, exposed areas across range.

*HEMIZONIA CONGESTA* DC. subsp. *LUZULAEFOLIA* Bab. and Hall. Dry slopes, west side and interior of range.

*HEMIZONIA FASCICULATA* (DC.) Torr. and Gray. Hillslope, Arroyo Mocho.

*HEMIZONIA VIRGATA* Gray. Abundant and conspicuous element of aestival flora on dry hillsides across range.

*HEMIZONIA HEERMANNII* Greene. (*H. virgata* Gray var. *Heermannii* Jepson.) Growing in similar habitats to *H. virgata*, east side and interior of range.

*HEMIZONIA KELLOGGII* Greene. (*H. Wrightii* Gray var. *Kelloggii* Jepson.) Occasional in flood beds of streams, interior and east side of range.

*HEMIZONIA OBCONICA* Clausen and Keck, type from near Tesla, Mount Hamilton Range, Keck and Stockwell 2501 (S). A species frequently confused with *H. virgata*.

*HEMIZONIA PLUMOSA* (Kell.) Gray (*Calycadenia plumosa* Kell.; *Blepharizonia plumosa* Greene; *B. laxa* Greene.) Rocky dry slopes, east side of range.

*CALYCADENIA VILLOSA* DC. (*Hemizonia villosa* (DC.) Jepson.) Colorado Creek, Keck 2487 (S).

*CALYCADENIA TRUNCATA* DC. (*Hemizonia truncata* Gray.) Dry, exposed areas, frequent in aestival flora across range.

*CALYCADENIA HISPIDA* Greene. Dry areas, interior and east side of range. Santa Isabella Valley, C. W. and H. K. Sharsmith 1369 (UC); San Antonio Valley, C. W. and H. K. Sharsmith 1379 (UC). The typical phase of the species is not represented in the Mount Hamilton Range; these collections should probably be referred to a subspecies.

*CALYCADENIA MULTIGLANDULOSA* DC. (*Hemizonia multiglandulosa* Gray.) Occasional on dry slopes, interior of range.

*CALYCADENIA CEPHALOTES* (Gray) Greene. (*Hemizonia multiglandulosa* var. *cephalotes* Gray; *H. cephalotes* Greene; *Calycadenia multiglandulosa* var. *cephalotes* Jepson.) Grassy, open slopes, Mount Hamilton.

*MADIA MADIOIDES* (Nutt.) Greene. West side of range on wooded slopes, infrequent.

*MADIA ELEGANS* Don. subsp. *TYPICA* Keck. (*M. elegans* var. *hispida* Hall.) Occasional across range on dry, rocky slopes.

*MADIA RADIATA* Kellogg. Hospital Canyon, Chamberlin 6196 (S), Hoover 3065 (UC). A distinctive species which occurs in isolated localities on the eastern margin of the inner South Coast Ranges from Antioch, Contra Costa County, to San Luis Obispo County.

*MADIA SATIVA* Mol. subsp. *DISSITIFLORA* (Nutt.) Keck. (*M. dissitiflora* Torr. and Gray.) Dry slopes, west side and interior of range.

*MADIA EXIGUA* (Smith) Gray. (*Harpaecarpus exiguus* Gray.) Occasional on exposed slopes across range.

*LAYIA CHRYSANTHEMOIDES* (DC.) Gray. Very abundant in Santa Isabella Valley, forming extensive pure colonies or mixed with *L. platyglossa*.

*LAYIA PLATYGLOSSA* (Fisch. and Mey.) Gray. (*Blepharipappus platyglossus* Greene.) Frequent vernal annual, valley flats across the range.

*LAYIA GAILLARDIODES* (Hook. and Arn.) DC. Frequent on grassy or rocky slopes across range.

*LAYIA HIERACIODES* (DC.) Hook. and Arn. In chaparral, interior of range.

*HEMIZONELLA MINIMA* Gray. Occasional in chaparral, interior of range. Arroyo Bayo, H. K. Sharsmith 1705 (UC); Burnt Hills, H. K. Sharsmith 3457; Copernicus

Peak, *H. K. Sharsmith 3712* (UC). The first records of this species in the South Coast Ranges.

*LAGOPHYLLA RAMOSISSIMA* Nutt. subsp. *TYPICA* Keck. Frequent aestival annual across range in exposed regions.

*LAGOPHYLLA RAMOSISSIMA* Nutt. subsp. *CONGESTA* (Greene) Keck. Infrequent, valley areas across range.

*HOLOZONIA FILIPES* (Hook. and Arn.) Greene. Dry streamlets, interior of the range. Santa Isabella Valley, *H. K. Sharsmith 3332* (UC); Arroyo Bayo, *H. K. Sharsmith 3866* (UC). Not before collected in the South Coast Ranges.

*ACHYRACHAENA MOLLIS* SCHAUER. Occasional on dry, open areas across the range.

*\*XANTHIUM SPINOSUM* L. Abandoned farmyard, Mount Day Ridge.

*LASTHENIA GLABRATA* Lindl. Heavy adobe, Hall's Valley.

*LASTHENIA GLABERRIMA* DC. Vernal pool, Santa Isabella Creek.

*BAERIA CHRYSOSTOMA* Fisch. and Mey. Vernal annual, valley floors across range.

*BAERIA CHRYSOSTOMA* var. *GRACILIS* (DC.) Hall. (*B. gracilis* Gray.) Vernal annual, area of preceding but more common.

*BAERIA ULIGINOSA* (Nutt.) Gray. Valley flats, east side of range.

*BAERIA MICROGLOSSA* (DC.) Greene. Moist areas, interior and east side of range, infrequent.

*MONOLOPIA MAJOR* DC. Very abundant in isolated colonies, open hillsides, east side of range.

*MONOLOPIA LANCEOLATA* Nutt. Open hillsides, east side of range, frequently mingling with the above species.

*ERIOPHYLLUM WALLACEI* Gray. Several plants of this species were collected in the dry, gravelly stream bed near the headwaters of Arroyo Mocho, September 24, 1933, C. W. and *H. K. Sharsmith 441*. The plants were identified by L. Constance. Later they were lost, and none were found in subsequent seasons. The species is characteristic of the Colorado and Mohave deserts and the dryer interior valleys of southern California, extending into the Great Basin to the east. One specimen is in the University of California herbarium from Bakersfield, but otherwise the species appears not to have been collected outside of the areas mentioned above. Its infrequent occurrence in the inner South Coast Ranges north to the Mount Hamilton Range is not improbable, however, on the basis of the over forty other typically desert species which have been found to have this same distribution.

*ERIOPHYLLUM CONFERTIFLORUM* (DC.) Gray. Frequent shrub on rocky hillsides, interior of range.

*ERIOPHYLLUM JEPSONII* Greene, type from hills between Arroyo Mocho and Arroyo del Vallé, north end Mount Hamilton Range, May, 1891, *Jepson*. Frequent chaparral associate, interior and east side of range; restricted to Mount Diablo, Mount Hamilton Range, and San Carlos Range. In the area between Arroyo Bayo and Santa Isabella Valley where *E. jepsonii* and *E. confertiflorum* occur together, typical plants of both species are found in the chaparral along with plants which share the characteristics of both, an indication that the two species hybridize.

*ERIOPHYLLUM LANATUM* (Pursh) Forbes var. *ACHILLAEODES* (DC.) Jepson. Arroyo Mocho, *Elmer 4335*, isotype (UC1) of *E. Greenei* Elmer, Bot. Gaz. 41:313. 1906.

*RIGIOPAPPUS LEPTOCLADUS* Gray. Frequent vernal annual on rocky slopes across range.

*CHAENACTIS HETEROCARPHA* Gray. (*Chaenactis glabriuscula* DC. var. *heterocarpha* (Gray) Hall.) Frequent in chaparral, interior and east side of range, often on serpentine.

*HULSEA HETEROCHROMA* Gray. Chaparral clearing, divide between Arroyo Mocho and Colorado Creek, *H. K. Sharsmith 959* (UC). Infrequent in the South Coast Ranges, known from isolated stations only.

*HELENIUM PUBERULUM* DC. Near streams, west side and interior of range; infrequent.

*ACHILLEA LANULOSA* Nutt. (*A. millefolium* L. var. *lanulosa* (Nutt.) Piper.) Frequent on dry slopes across range.

\**MATRICARIA MATRICARIOIDES* (Less.) Porter. (*M. suaveolens* (Pursh) Buch.; *M. discoidea* DC.) Common only near the cultivated margins of range.

*ARTEMISIA CALIFORNICA* Less. Frequent on exposed hillsides, west and east margins of range, not occurring in the interior.

*ARTEMISIA VULGARIS* L. var. *CALIFORNICA* Besser. (*A. vulgaris* var. *heterophylla* Jepson; *A. Douglasiana* Besser.) Occasional along streams across range.

*ARTEMISIA DRACUNCULUS* L. (*A. dracunculoides* of authors, non Pursh.) Occasional at stream margins, west side and interior of range.

*CROCIDIUM MULTICAULIS* Hook. Occasional on grassy slopes, interior of range. The Mount Hamilton Range is the only known locality in the South Coast Ranges for this northern species.

*SENECIO DOUGLASHI* DC. Frequent shrub; exposed dry slopes across range.

*SENECIO ARONICOIDES* DC. Brush slopes or in chaparral, occasional on west side of range.

*SENECIO BREWERI* Davy. Infrequent on wooded slopes, interior and east side of range. Seeboy Ridge, *H. K. Sharsmith 1978* (UC); San Antonio Valley, *H. K. Sharsmith 3086* (UC); Adobe Valley, *H. K. Sharsmith 3559* (UC). A desert species occurring north in the inner South Coast Ranges to the Mount Hamilton Range, closely related to *S. eurycephalus* Torr. and Gray of the North Coast Ranges and considered as synonymous with this latter species by Hall (Univ. Calif. Publ. Bot. 3:233. 1907). *Senecio Breweri* is quite glabrous, whereas *S. eurycephalus* is floccose or white tomentose, becoming glabrate with age. Hall considered these differences in pubescence to be related to habitat, the tomentose plants growing in less arid soil. This view, however, is not consistent with the geographic distribution of the two species and the localities occupied. *Senecio Breweri* is also distinguished from *S. eurycephalus* by more leaflets per leaf, more numerous heads, a corymbose inflorescence, and broad involucre bracts.

\**SENECIO VULGARIS* L. Occasional, lower western slopes of range.

*ARNICA DISCOIDEA* Benth. Wooded slopes, Mount Hamilton.

*ARNICA CORDIFOLIA* Hook. (*A. latifolia* of authors.) Wooded slopes, west side of range.

*LEPIDOSPARTUM EQUAMATUM* Gray. Dry streambed, Arroyo Mocho, *H. K. Sharsmith 444* (UC); Eylar Mountain, *Lundh 27* (VTM); Hospital Canyon, *Lundh 115* (VTM). Predominately a Great Basin and desert species; these are the first records of the species in the Mount Hamilton Range, apparently its northern limit of distribution.

*CIRSium LANCEOLATUM* (L.) Hill. Moist soil, Mount Day Ridge.

*CIRSium CAMPYLON* H. K. Sharsmith, *Madroño 5:85*. 1939, type from Arroyo del Puerto, Red Mountains, Mount Hamilton Range, *H. K. Sharsmith 3761* (UC!), isotypes (G,K). *Cirsium campylon* is restricted to the Mount Hamilton Range. It forms dense but isolated colonies in moist, sandy soil along edges of small, perennial streams, all known localities occurring in areas of serpentine rock.

*CIRSium CALIFORNICUM* Gray. (*Carduus californicus* Greene.) Occasional on dry slopes, west side and interior of range. Smith Creek, *H. K. Sharsmith 1177* (UC); Grand View, *Pendleton 852* (UC); San Antonio Creek, *H. K. Sharsmith 3199* (UC); San Antonio Valley, *H. K. Sharsmith 3098* (UC). In the short peduncles and clustered heads, these specimens do not represent typical *C. californicus*. Collection 3199 is particularly atypical in these characteristics.

*CIRSium OCCIDENTALE* (Nutt.) Jepson var. *COULTERI* (Harv. and Gray) Jepson. Occasional on dry slopes across range.

\**CENTAUREA MELITENSIS* L. Cultivated areas, west base of range; also near a few abandoned homesites, interior of range.

#### *Species to be expected in the Mount Hamilton Range*

The following list consists of species which have been reported from the Mount Hamilton Range, but which have not been collected by the writer, nor have specimens been located in the herbaria consulted:

*FESTUCA MYUROS* L. Greene, *Erythea 1:97*. 1893, Mount Hamilton.

*ERIOGONUM HIRTIFLORUM* Gray. Greene, *op. cit.*, p. 84. Mount Hamilton. This species reaches its best development in the chaparral areas of Lake County, but it has been recently reported from the Pinnacles of San Benito County in the South Coast Ranges (Howell, Leaf. West. Bot. 2:99. 1938), and on the basis of this record and that of Greene, it is probable that it occurs in the Mount Hamilton Range.

*LUPINUS NANUS* Dougl. Heller, Muhl. 2:292. 1907 (as *L. carnosulus* Greene), Alum Rock Park; Jepson, Fl. Calif. 2:272. 1936 (as var. *apricus* C. P. Smith), Mount Hamilton.

*EPILOBIUM CALIFORNICUM* Hausskn. Greene, Erythea 1:86. 1893, Joaquin [Murieta] Springs.

*OSMORHIZA OCCIDENTALIS* (Nutt.) Torr. Greene, *op. cit.*, p. 89 (as *Myrrhis occidentalis* (Nutt.) Benth. and Hook.), Mount Hamilton.

*CICUTA DOUGLASHII* Coult. and Rose. Greene, *op. cit.*, p. 89 (as *Cicuta californica* Gray), Joaquin [Murieta] Springs.

*CHIMAPHILA MENZIESII* (R. Br.) Spreng. Greene, *op. cit.*, p. 92 (as *Pseva Menziesii* (R. Br.) O. Ktze.), Mount Hamilton.

*APOCYNUM ANDROSAEMIFOLIUM* L. Greene, *op. cit.*, p. 92, Mount Hamilton.

*PHACELIA NEMORALIS* Greene. Greene, *op. cit.*, p. 93 (as *P. circinata* (Willd.) Jacq.), Mount Hamilton.

*OROBANCHE TUBEROSA* (Gray) Heller. Greene, *op. cit.*, p. 95 (as *Aphyllon tuberosum* Gray), Mount Hamilton.

The following are introduced species which Greene reported from the summit of Mount Hamilton, but which have not been collected by the writer, nor have herbarium specimens been located:

*POLYGONUM AVICULARE* L. Greene, Erythea 1:83. 1893.

*CHENOPODIUM MURALE* L. Greene, *op. cit.*, p. 85.

*AMARANTHUS ALBUS* L. Greene, *op. cit.*, p. 84.

*AMARANTHUS RETROFLEXUS* L. Greene, *op. cit.*, p. 84.

*BRASSICA NIGRA* (L.) Koch. Greene, *op. cit.*, p. 87.

*MAIWA PARVIFLORA* L. Greene, *op. cit.*, p. 83.

*SONCHUS OLERACEUS* L. Greene, *op. cit.*, p. 92.

*ANTHEMIS COTULA* L. Greene, *op. cit.*, p. 91.

*CENTAUREA SOLSTITIALIS* L. Greene, *op. cit.*, p. 91.

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## **Asclepias syriaca and *A. speciosa*, Distribution and Mass Collections in North Dakota<sup>1</sup>**

O. A. Stevens

When milkweed floss was found to be a strategic war material and extensive collections from wild plants were desired, the identification of these two closely related species became a subject on which more information was needed. The literature referred chiefly to *A. syriaca*. Was *A. speciosa* equally desirable and could it be distinguished in the field? The plants of the two species are very similar but *A. speciosa* is readily distinguished in flowering condition by the few-flowered clusters of much larger flowers.

In connection with an experiment station project on the cultivation of *A. syriaca* for the past two years, the writer has made mass collections of leaves of both species and kept notes on their distribution and abundance in this area. The map in Figure 1 shows the portions of North Dakota traversed and the abundance of both species. In general, only *A. speciosa* occurs west of the Missouri River. In the eastern part of the State, *A. syriaca* predominates, but *A. speciosa* occurs and may be common locally. In the east-central part, either species may be encountered, and especially in cultivated or disturbed soil, they often occur together.

Both species seem rather closely limited to moist places. They are most often seen along roadside banks or shallow ditches, and usually as only a few stems per colony. Occasionally they are abundant in low fields. It has been noticeable that plants are rarely found along highways which have been built recently across ground formerly cultivated, but are frequent along old roads. Both species seem rather indifferent to soil type. Both grow well on sand with a high water table.

Assumption had been made that *A. speciosa* could be recognized by the ovate rather than oblong leaves and the long white tomentum in the axil. Both species are quite variable in leaf form and while the plants usually can be determined by that character, it seems not entirely reliable. Table 1 presents an analysis of leaf size and shape based upon 37 collections of 844 leaves. In general, leaves were taken from flowering stalks only, one leaf from an average stalk in each colony. A leaf just below the lowest flower cluster was used. Since many of the collections were made in fields and along roadsides, some of the colonies may have been vegetatively multiplied by roots carried by road grading or tillage implements.

The term "colony" is used here rather than "clone." With the exception of No. 785, which was grown from roots taken from a limited area, the collections were composed of several to many leaves, one each from as many

<sup>1</sup> Contribution from Department of Botany, North Dakota Agricultural Experiment Station. Published with the approval of the director.

colonies. Most of the colonies probably are clones, but may be mixed. Nos. 792-800 are believed to be clones and one leaf was taken from each fertile stalk.

The measurements and shape classes show that *syriaca* has a decided tendency to an oblong leaf but only about half of the total number were classed as oblong. *Speciosa* shows a much greater tendency to an ovate leaf (80% of cases). Its leaves average shorter but not narrower, though some lots are narrow enough to give a width-length ratio lower than the usual ratio for *syriaca*. Material from several colonies of *speciosa* was brought in by Dr. E. A. Helgeson, collected from Stutsman to Stark Counties. The leaves from different stalks in a colony show a high degree of similarity while there are considerable differences between those of different colonies. (See Table 1 (Nos. 792-800) and Figure 2.)

Leaf bases in *syriaca* are usually truncate, rounded or narrowed. In the table these are all listed under "rounded." There is a slight tendency in *syriaca* for the base to be cordate and this is very pronounced in *speciosa*. The two species differ little in the apex, though there is a slightly greater tendency toward acute in *syriaca* in connection with the frequent lanceolate shape. The usual apex is obtuse but apiculate. Several cases of bi-lobed leaves have been noted, the midrib having divided at some point. Occasionally a rounded apex seems to have resulted from a minor degree of such disturbance. Samples of shape types are shown in Figure 2.

Flower characters show considerable variation but have not been studied in as much detail. The diameter of the flower is approximately 10 mm. (measured from tip of 1st to 3rd hood) for *syriaca* and 20 mm. for *speciosa*. One flower each from 25 colonies of *syriaca* at Kindred, Cass County, ranged from 8 to 12 mm. averaging 10.2 mm., if three which measured 15, 17 and 18 mm.

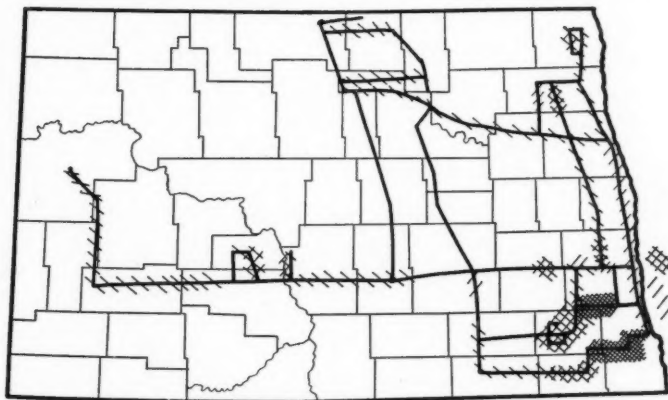


Fig. 1. Abundance of *Asclepias syriaca* /// and *A. speciosa* ≡ in North Dakota, as indicated by three densities of shading.



TABLE 1.—Leaf size and shape in *Asclepias syriaca* and *A. speciosa*; representative lots with totals and weighted averages for all lots.

| Collection<br>number            | No. of<br>leaves | Size in centimeters   |        | Ratio —<br>Av. length<br>width | Predominant shape—no. each |          |            | Base    |         |         | Apex   |       |    |
|---------------------------------|------------------|-----------------------|--------|--------------------------------|----------------------------|----------|------------|---------|---------|---------|--------|-------|----|
|                                 |                  | Av. greatest<br>width | Oblong |                                | Ovate                      | Elliptic | Lanceolate | Cordate | Rounded | Rounded | Obtuse | Acute |    |
| <i>A. syriaca</i>               |                  |                       |        |                                |                            |          |            |         |         |         |        |       |    |
| 737                             | 49               | 14.6                  | 7.0    | .48                            | 33                         | 12       | 1          | 3       | 4       | 45      | 10     | 34    | 5  |
| 749                             | 35               | 14.0                  | 6.3    | .45                            | 17                         | 12       | 3          | 3       | 0       | 35      | 6      | 14    | 15 |
| *785                            | 36               | 14.7                  | 5.8    | .39                            | 12                         | 5        | 1          | 18      | 0       | 36      | 0      | 25    | 11 |
| 786                             | 48               | 14.0                  | 6.5    | .46                            | 27                         | 9        | 12         | 0       | 0       | 48      | 19     | 28    | 1  |
| 787                             | 51               | 14.0                  | 6.4    | .46                            | 17                         | 24       | 7          | 3       | 0       | 51      | 14     | 32    | 5  |
| 788                             | 47               | 13.9                  | 6.1    | .44                            | 27                         | 14       | 3          | 3       | 0       | 47      | 11     | 28    | 8  |
| Totals and avgs.<br>of all lots |                  | 14.5                  | 6.7    | .47                            | 224                        | 142      | 48         | 52      | 19      | 447     | 127    | 247   | 92 |
| <i>A. speciosa</i>              |                  |                       |        |                                |                            |          |            |         |         |         |        |       |    |
| 707                             | 32               | 12.3                  | 7.0    | .57                            | 10                         | 21       | 1          | 0       | 13      | 19      | 9      | 23    | 0  |
| 735                             | 27               | 10.0                  | 7.3    | .73                            | 1                          | 25       | 1          | 0       | 13      | 14      | 11     | 16    | 0  |
| 751                             | 26               | 12.7                  | 6.5    | .51                            | 3                          | 21       | 0          | 2       | 2       | 24      | 4      | 16    | 6  |
| 790                             | 28               | 10.9                  | 6.1    | .56                            | 3                          | 23       | 1          | 1       | 11      | 17      | 7      | 17    | 4  |
| *792                            | 21               | 12.9                  | 9.5    | .74                            | 0                          | 21       | 0          | 0       | 21      | 0       | 9      | 12    | 0  |
| *795                            | 17               | 11.9                  | 6.7    | .56                            | 7                          | 10       | 0          | 0       | 17      | 0       | 14     | 3     | 0  |
| *797                            | 15               | 9.4                   | 6.3    | .67                            | 0                          | 15       | 0          | 0       | 15      | 0       | 15     | 0     | 0  |
| *800                            | 16               | 10.1                  | 5.1    | .50                            | 0                          | 15       | 0          | 1       | 0       | 16      | 0      | 4     | 12 |
| Totals and avgs.<br>of all lots |                  | 11.1                  | 6.5    | .56                            | 57                         | 295      | 10         | 16      | 151     | 227     | 129    | 199   | 50 |

\* Single colonies; 785 Fargo, 792-800 Sutsman to Stark Counties.

each be excluded. These large ones are believed to be hybrids. From the same area, 20 flowers from *speciosa* colonies ranged from 13 to 30 mm. (av. 20.0). This greater size of *speciosa* is due in part to general size, but especially to elongated and widely spreading hoods. In *syriaca* the hoods are usually slightly spreading, sometimes erect, sometimes markedly spreading. In *speciosa* they are usually widely spreading, sometimes almost horizontal. In three cases of the above lot (each 20 mm. wide) they were incurved at the tips.

A field plot of *syriaca* was planted at Fargo in 1943, using both seeds and roots from three locations in Cass County: Fargo, Casselton and Amenia.<sup>2</sup> The roots from Fargo happened to be a very unusual strain which produced short stems, narrow leaves (No. 785, Table 1) and approximately 30 percent of flowers 6-parted. Such flowers were practically absent in plants grown from seeds collected at the same place.

<sup>2</sup> A further report upon this has appeared in N. Dak. Agr. Exp. Sta., Bull. 333, Cultivation of milkweed, *Asclepias syriaca* in North Dakota.

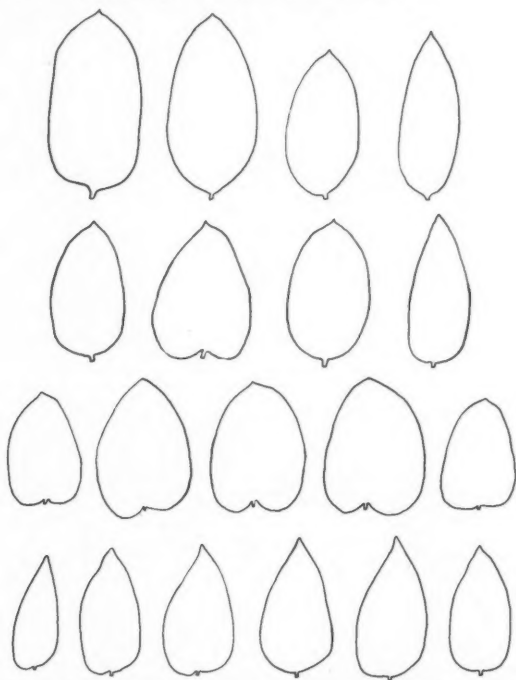


Fig. 2. Leaf types in *Asclepias syriaca* and *A. speciosa*. First row: oblong, ovate, elliptic and lanceolate leaves from *A. syriaca* No. 788; second row: same from *A. speciosa* No. 791; third row: variations from individual stalks from *speciosa* colony No. 797; fourth row: same from *speciosa* colony No. 800.

Among fruits collected at Amenia in 1942, were some with unusually large seeds. The following year more careful examination of the plants in that area was made, eight colony types marked and collected in fruit, but none of the large seeds were found. In the row grown from the large seeds the following flower types were marked on July 15 for further study. These will serve as a sample of the diversity which has been observed to be general.

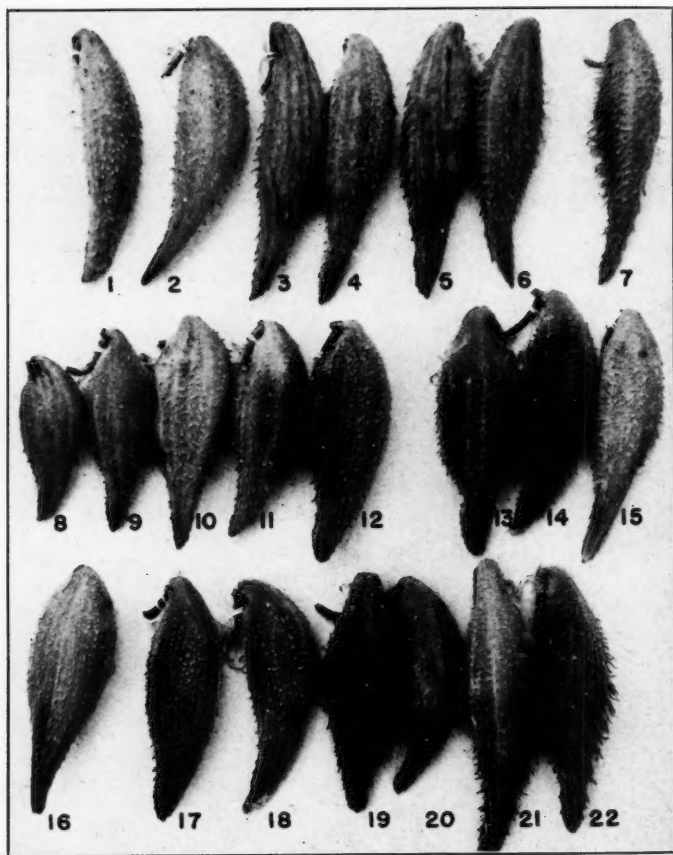


Fig. 3. *Asclepias syriaca* fruits. All from experimental plot at Fargo, August 29, 1944. Nos. 1-11 from Amenia large seed flower types indicated on page 373; 12, 15, 17, 18, 19 from Fargo seeds; 16 from Fargo roots; 14, 20, 21, 22 from Casselton seeds. No. 13 an inflated type with shallow depressions. No. 8 was 6.5 cm. and No. 21 was 11.5 cm. long.

Flower variants in plants grown from large-seeded *A. syriaca* fruits. Fruits by same lot number are shown in Figure 3.

|   |     |
|---|-----|
| Flowers dark  |     |
| Hoods acuminate, fls. 11 mm., 50 per cluster .....                  | S7  |
| Hoods rounded, fls. 10 mm., 15 per cluster, pedicels 30-35 mm. .... | S3  |
| Flowers medium  |     |
| Hoods blunt, fls. 10 mm. ....                                       | S5  |
| Hoods blunt, fls. 12 mm., 50 per cluster .....                      | S11 |
| Hoods rounded, fls. 12 mm., 50 per cluster .....                    | S4  |
| Hoods rounded, fls. 9 mm., 25 per cluster .....                     | S10 |



Fig. 4. Flower cluster of supposed hybrid (No. 775). Individual flowers of hybrid *syriaca* and *speciosa* below. Dilworth, Minnesota, July 18, 1944.

## Flowers pale

|   |    |
|---|----|
| Hoods blunt, fls. 10 mm., turning dark red with age, late flowering ..... | S2 |
| Hoods blunt, fls. 10 mm., 25 per cluster, turning dark .....              | S6 |
| Hoods acuminate, fls. 12 mm., not turning dark .....                      | S9 |
| Hoods acuminate, fls. 10 mm., 40 per cluster, not turning dark .....      | S1 |
| Nearly out of bloom, fls. 8 mm., pedicels short, about 20 mm. ....        | S8 |

No. S4 seemed to be the most common (one-third of cases), with 7, 3, and 6 frequent, 9 and 11 less frequent, 1, 2, 5, 6, and 8 rare.

Since the present article was submitted for publication, W. G. Dore has described (Rhodora 46:387-8) a white flowered form of *Asclepias syriaca*, and commented on complete lack of anthocyanin in leaves and stem. I had not noted any plants as outstanding in this respect, though there was a wide variation in red color, especially in the midrib. Some of the flowers listed as "pale" were nearly white.

These characters do not appear sharply defined, yet they are often striking. Pedicel length needs further study, especially in relation to stage of development. Some plants did not bloom the second year and there were differences in vegetative vigor which might or might not continue through later seasons.

Fruits from the above plants and a few others in the plot are shown in Figure 3. There is much variation in size and shape of fruits and length of processes. Opportunities for study of fruits of *speciosa* have been quite limited but it appears to show similar variation. The seeds of different lots of *syriaca* have differed in size, shape and shades of brown. From limited observations, there seems to be no marked distinction between the two species in seed characters.

A form believed to be a hybrid is illustrated in Figure 4 from a specimen collected near Dilworth, Minnesota (No. 775), about two miles east of Fargo, where both species were common in a field and three distinct colonies of this form were observed. It has been noted at various other places but usually not as well marked colonies. The flowers seem intermediate between *syriaca* and *speciosa*, both as to size and number per cluster. The leaves seem more nearly like those of *syriaca*, and in this case were quite small and narrow (10.7 x 4.5 cm.).

## SUMMARY

Measurements of 844 leaves from 37 collections show that average width is the same for each species but *A. syriaca* is longer with a width-length ratio of .47, as compared with .56 for *speciosa*. The leaves were also grouped in classes by shape, base and apex. *A. syriaca* tends to be oblong; *A. speciosa* is commonly ovate, often with a cordate base. Variation in flower size and shape is discussed and fruit forms in *A. syriaca* are illustrated. A supposed hybrid between the two species is illustrated. *A. syriaca* is common in eastern North Dakota where *A. speciosa* also occurs. Both species occur through the east-central part of the state, only *A. speciosa* in the western part.

## Supplementary Notes on the Genus *Polemonium*

Edgar T. Wherry

In the three years since the appearance of the writer's review of the genus *Polemonium*<sup>1</sup> sufficient new data have accumulated to warrant a supplementary publication. First of all, it has been decided to name and formally describe the Nevada plant mentioned on page 749, in that sufficient material is now available to show that it is not a mere freak. It may be known as:

### *Polemonium nevadense* Wherry, species nova. FIG. 1

Rootstock stout, suberect, branched upward; herbage fine-pubescent, the hairs gland-tipped toward the inflorescence; basal leaves tufted, up to 12 cm. long, the petiole shorter than the blade; cauline few, remote; leaf-blades subterete, the leaflets being irregularly verticillate; leaflets up to 30 per leaf, mostly free, narrow-elliptic or the terminal oblanceolate, to 18 mm. long and 8 mm. wide, acutish to obtusish; flowering shoots few, 10 to 15 cm. high, terminating in a rather small thyrsus of few-flowered cymes; pedicels 1 to 7 mm. long; sepals in anthesis 6 mm. long, united half their length, their blade narrowly deltoid, acuminate; corolla "pale blue-lavender," rotate-campanulate, when closed about 10 mm. long and when open 12 mm. across; stamens included, subequal, spreading, the anthers yellow; styles about 7 mm. long, equalling the closed corolla.

Rhizoma crassum, ramosum; folia usque ad 12 cm. longa, brevipetiolata; foliola irregulariter verticillata, anguste elliptica, usque ad 18 mm. longa et 8 mm. lata; thyrsus minor; sepala ad anthesem 6 mm. longa, dimidio conjuncta, laminis anguste-deltoides; corolla rotato-campanulata, ca. 12 mm. lata; stamina subaequalia, inclusa; styli ca. 7 mm. longi.

Type in herbarium Academy Natural Sciences Philadelphia; replicates in herbaria of U. S. National Arboretum and University Nevada. Collected by Percy Train July 9, 1937, No. 347, uncommon on east cliffs, Hinkey Summit, Santa Rosa range, Humboldt County, Nevada, at 8200' altitude.<sup>2</sup> An earlier collection is represented in the herbarium of the U. S. Forest Service: Bryant S. Martineau July 2, 1915, No. 107, divide at head of McConnell Creek, at 8400' altitude, in same general region.

While this entity falls into the verticillate-leaflet group, Section *Melliosma*, it actually connects this group with Section *Eupolemonium*: beside the leaflet-arrangement, it resembles other members of *Melliosma* in compact inflorescence and narrow sepal-blades; yet its leaflets are larger than those of any others, and in its short open corolla it is quite unlike the typical *Melliosmas*. Of the members of *Eupolemonium* it apparently lies nearest to *P. haydeni*.

<sup>1</sup> Amer. Midl. Nat. 27:741, 1942.

<sup>2</sup> Hinkey Summit is not on maps, but according to the U.S. Forest Service is in Sec. 26, T. 44 N., R. 39 E., southwest from Martin Guard Station.



Occurrences of thyrsoid *Polemoniums* in the Great Lakes region may receive attention next. In the U. S. National Herbarium there is preserved a specimen of a member of this group, collected after the corollas had fallen, attributed merely to "Michigan." This might have been ignored as representing a cultivated plant, were it not that the late O. A. Farwell some years ago assured me that he had found a thyrsoid *Polemonium* in that state, although he submitted no specimens nor furnished details.

More recently Miss Olga Lakela of Duluth, Minnesota, has sent me excellent material of a member of the thyrsoid group from a station in the northern part of that state, where there seems no question as to the plant's being native. Rocky mountain species of a number of genera being well known to extend east into the Great Lakes region, comparison of the plant with *Polemonium occidentale* seemed in order. As no differences which could reasonably be regarded as of species significance could be detected, it has been decided to describe the Minnesota entity as a subspecies:

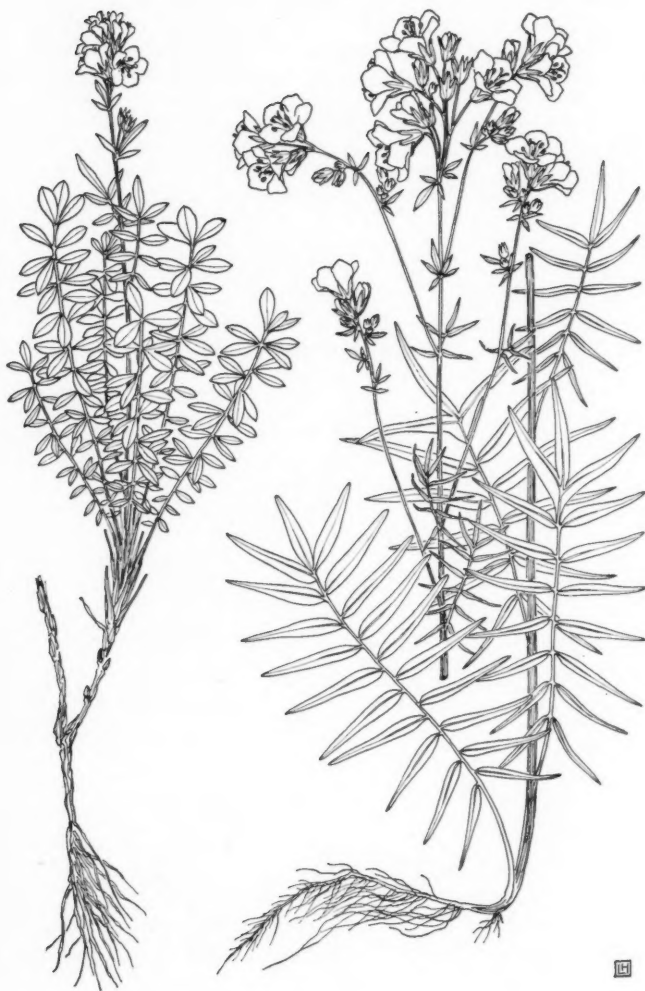
*Polemonium occidentale lacustre* Wherry, subspecies nova. FIG. 2

Rootstock slender, horizontal, producing a solitary stem 50 to 75 cm. tall, glabrous below and dense-pilose above, the hairs viscid but not gland-tipped; leaves up to 20 cm. long, the petiole about half the total, moderately reduced at successive nodes upward; leaflets 25 or fewer, all free or on middle leaves the terminal 3 confluent, linear-lanceolate, their maximum length 45 and width 7 mm., though mostly considerably smaller; inflorescence a thyrsoid panicle, formed by the branching of the terminal third of the stem; sepals at anthesis 6 to 7 mm. long, united about half their length, the blades deltoid-oblong, acutish; corolla medium-sized, about 15 mm. broad, bright violet, the eye paler and purple-striate, the petal-blades obtuse; stamens spreading, shorter than the petals, the anthers yellow; styles included; blooming period midsummer; later producing sterile shoots with leaves up to 30 cm. long; and on fertile shoots the sepals increasing at least  $\frac{1}{3}$  in length.

Rhizoma tenue, caulem solitarium 50-75 cm. altum superne viscido sed eglanduloso-pilosum ferens; folia usque ad 20 cm. longa, ad nodos succedentes aliquanta diminuenda; foliola lineari-lanceolata, in numero 25 minusve, tota libera vel 3 confluenta, usque ad 45 mm. longa et 7 mm. lata, plerumque minora; inflorescentia thyrsoido-paniculata; sepala ad anthesem 6-7 mm. longa, dimidio conjuncta, laminis deltoideo-oblongis, acutiusculis, valde accrescentibus; corolla ca. 15 mm. lata, laminis petalorum obtusis; stamina stylique inclusa; antherae luteae.

Type in herbarium Academy Natural Sciences Philadelphia; replicates in herbarium University Minnesota. Collected by Olga Lakela, No. 5575, July 2, 1944, from a colony an acre or more in extent in an arbor-vitae swamp  $3\frac{1}{2}$  miles north of Sturgeon Lake Observation Tower (47° 50, 93° 00), St. Louis Co., Minnesota.

Differences from *P. occidentale typicum* comprise: pubescence eglandular; leaves only moderately diminished in size up the stem; and inflorescence branched into a thyrsoid panicle.

FIG. 1. *Polemonium nevadense*.FIG. 2. *P. occidentale lacustre*.

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Comparison should also be made with the other members of the thyrsoid group. The eastern *P. vanbruntiae* differs in having much broader leaflets and in the stamens and styles being exserted. The northern *P. acutiflorum* has larger flowers with the corolla-lobes acute. Available data on the Eurasian *P. coeruleum* are insufficient to differentiate it sharply from the west-American entities. To be sure Greene<sup>1</sup> held that there is a rootstock-difference, but he apparently gained his conception of the rootstock of *P. coeruleum* from cultivated material, for there are specimens of this from various localities in Europe preserved in American herbaria which have slender rootstocks turned up at the tip into solitary stems quite as in *P. occidentale*. However, in *P. coeruleum* the pubescence seems to be normally glandular, and the inflorescence is branched only in exceptionally robust individuals instead of in average members of a colony as in the entity under consideration.

#### A CORRECTION

Some years ago I received a request from an English horticultural writer, Mr. Sampson Clay, for photographs of American rock plants, and a few of these were published in his work, *The Present Day Rock Garden*, London, 1937. The *Polemonium* figured on plate 39, facing page 480, had been identified, in accordance with such keys as were available at the time, to be *P. elegans* Greene. Then, when the studies for my 1942 paper were in progress, I regretted to find that it represented *P. pulcherrimum* Hooker instead. Fortunately the remarks in Mr. Clay's text require no change, for the essential difference between these two entities concerns corolla-shape.

#### ASSIGNMENTS OF CERTAIN EPITHETS TO NEW STATUS

In accordance with the principles that entities cannot be synonymous unless based on the same type specimen, and that every epithet validly published should be assigned some definite status, the following combinations remain to be made:

"*P. foliosissimum albiflorum* var. *alpinum*" Brand Pol.: 34, 1907, may become *P. f. a. f. alpinum* (Brand) Wherry, stat. nov. Differs from the typical form of the subspecies only in the leaves having up to 21 instead of 15 leaflets.

"*P. quadriflorum*" Raf. Atl. J. 1 (6): 177, 1833, was dismissed in the previous article, but deserves some consideration. It is therefore here made *P. reptans* L. f. *quadriflorum* (Raf.) Wherry, stat. nov. Differing from the typical form in having confluent terminal leaflets.

"*P. reptans* var. *macrophyllum*" Brand Pol.: 33, 1907, occurs sporadically in normal colonies of the typical form, especially around the southern end of Lake Michigan; it may become *P. reptans* L. f. *macrophyllum* (Brand) Wherry, stat. nov. Leaflets up to 5 (6) cm. long.

<sup>1</sup> Pittonia 2:75. 1890.

MODIFICATIONS OF THE KEY TO AMERICAN POLEMONIUMS<sup>1</sup>

The new subspecies of *P. occidentale* can be keyed out on page 756 on the basis of its paniculate inflorescence.

Just below the middle of page 757 two subspecies of *Polemonium brandegeei* are keyed out on the basis of alleged differences in stamen position and corolla-length. Further study having indicated that there is no correlation in these features, and that the flowers of ssp. *mellitum* are not consistently shorter than those of ssp. *typicum*, it is recommended that the data as to corolla-length be stricken from the key-lines.

At the top of page 758 *Polemonium pauciflorum* is separated into three subspecies, the measurements given being taken from the original descriptions of the entities involved. Subsequent study of the type specimens, now segregated at the Gray Herbarium, indicates a misunderstanding to have arisen: the sepal-length given for ssp. *hinckleyi* proves to represent that following post-anthesis accrescence, while the corolla-lengths of all three entities need some corrections. This subdivision of the key, beginning with line 5, should therefore run:

COROLLA-LENGTH about 40 mm.

INFLORESCENCE-HERBAGE densely pilose.....*typicum*.

INFLORESCENCE-HERBAGE sparsely pilose.....*stenocalyx*.

COROLLA-LENGTH about 35 mm.; pubescence sparse throughout.....*hinckleyi*.

## THE GENUS POLEMONIUM IN CALIFORNIA

In May, 1943, there appeared the fascicle of Jepson's Flora of California—volume 3 part 2—which includes the *Polemoniaceae*. His treatment of the genus *Polemonium* differs so markedly from that of the present writer that some discussion of the discrepancies seems desirable. Referring first to points in the genus description upon which there are differences of opinion,—I hold that the common flower color is violet, on the basis of comparison of the corollas of numerous species with standard color guides; that there are far more than 14 species, it being possible to recognize without undue splitting 40 species in America and 10 in Eurasia, a total of 50; and that the genus epithet was given by Dioscorides not in reference to war, but in honor of a man named Polemon,—a philosopher, a teacher, or an ancient king. When we consider how violently writers on *Polemoniaceae* disagree, it seems prophetic that this individual should have been selected,—for his name means The Fighter!

Taking up now the several species, No. 1 is so different from the rest that much can be said in favor of placing it in the segregate genus *Polemoniella*; this is, however, a matter of opinion.

Coming to number 2, on the other hand, a question as to interpretation of types arises. Jepson gives for *P. pulcherrimum* elliptic leaflets 8 to 16 mm. long and styles exceeding corolla; considering as type the account of that entity published by Hooker,<sup>2</sup> the present writer holds that the name should be

<sup>1</sup> Amer. Midl. Nat. 27:756, 1942.

<sup>2</sup> Curt. Bot. Mag. 57: pl. 2979, 1830.

applied to plants with ovate leaflets 5 to 7 mm. long and the styles included. Jepson's figure 367 differs in these respects from Hooker's illustration, but corresponds to the type specimen of Miss Eastwood's *P. californicum*.

There is no disagreement as to the features of entity No. 3, *P. parvifolium* Nutt. ex Rydb., nor question as to its specific distinctness from *P. pulcherrimum* sensu Jepson, but there is a real question as to how it is related to *P. pulcherrimum* Hooker. I have been unable to recognize any essential differences in measurements of parts between these two entities. The Nuttall plant, to be sure, has the leaves shorter and the leaflets correspondingly closer together; but the Hooker plant had come originally from high elevations in British Columbia, and had been grown in the mild British climate, which might well have led to some increase in leaf length. I therefore would class Jepson's No. 2 as *P. californicum*, and No. 3 as *P. pulcherrimum* f. *parvifolium*.

As to species No. 4 and 5 there is no difference of interpretation so far as California material is concerned. The entity numbered 6 is so unlike the type of *P. confertum* Gray that assignment of it to varietal status under that seems undesirable. I therefore hold that *P. eximium* should be maintained as a species, and if any reduction is deemed necessary, that *P. chartaceum* should receive infra-specific status under it, not under an entity which is both morphologically and geographically remote.

Out of the 40 American *Polemoniums* I have ventured to recognize as worthy of species status, there are, then, 12 found in California. These fall into 8 groups: (1) *occidentale*; (2) *helleri*; (3) *carneum*; (4) *columbianum* with the reduced-corolla representative *calycinum* in the Lassen region; (5) *californicum* with the short-leaved, short-styled variant *tricolor* in the Marble Mt. region; (6) *pulcherrimum* with a confluent-leaflet relative *berryi* in the Lake Tahoe region; (7) *shastense*, the tiniest of the lot; and (8) *eximium*, with the exerted stamen and style derivative *chartaceum* in the White Mountain region. Should any reduction in status be called for, it should preferably be made within a group. But the aberrant entities referred to occur in regions famous for their endemic plants, and in other genera it is not considered necessary to hide endemism by reduction to synonymy.

#### AN ALTERNATIVE INTERPRETATION OF A CYTOLOGIC OBSERVATION

A map showing the distribution of *Polemonium reptans* and *P. vanbruntiae* has recently been published by Cain.<sup>1</sup> In the accompanying legend it was stated that "*P. Van Bruntiae* was reported by Flory as having the same number [as *P. reptans*, 18] but Dr. C. A. Berger, S.J., of Fordham University, has established that it is a tetraploid ( $s=36$ ).\" Actually, as had been brought out by several maps presented on preceding pages, when chromosome counts differing by simple integral multiples are obtained on a given species, it does not mean that one observer has been in error. Instead, it brings out the more interesting situation, that the species varies in ploidy. In this case, Dr. Flory had found that a plant of the southwestern area of *P. vanbruntiae* is diploid, and Dr. Berger that one from the northeastern area is tetraploid.

<sup>1</sup> Foundations of Plant Geography, page 462, 1944.

## Two Linanthoid Genera

Edgar T. Wherry

In 1940 the writer published a Provisional Key to the Polemoniaceae,<sup>1</sup> recognizing 18 genera divided among 4 tribes, with brief statements of the diagnostic characters and species content of each genus. For estimating the number of species included, the chief source of information was Brand's treatment of Polemoniaceae in Engler's Pflanzenreich IV. 250. Critical examination indicating, however, that his work was not uniformly well done, it was decided to review the genera one by one, and to try to straighten out various taxonomic tangles. Even though there would be no opportunity to prepare complete revisions, bringing together of the scattered literature and interpretation of entities in accordance with their descriptions and types seemed worth while.

The treatments published thus far cover *Polemonium*, *Polemoniella*, *Colomia*, and *Gymnosteris*.<sup>2</sup> In the present article two genera belonging to the *Linanthus* subdivision of the *Gilia* tribe are similarly covered. Taxonomists who are perturbed by the existence of occasional anomalous entities, which seem to bridge such gaps as are used in diagnostic keys, lump the groups concerned with the typical *Gilias* into a sort of super-genus bearing the latter name; but it is more convenient to maintain them as distinct.

### GILIA TRIBE: KEY TO LINANTHOID GENERA

PHYLLOTAXY opposite up to the inflorescence or, in a few shrubs, only at lower nodes; leaf-cutting of a palmate pattern, varying to pinnate through lobe-coalescence, or reduced to solitary subulate segments in a few cases; calyx more or less angled.....LINANTHUS Subtribe.

HABIT dwarf-shrubby to woody-based perennial.

CALYX-ANGLES produced by elevated costae; scarious junction-membranes broad; woody tissue well-developed .....1. *Leptodactylon*.

CALYX-ANGLES produced by paired thickenings at sepal-junctions; scarious junction-membranes narrow and obscure; woody tissue little-developed .....2. *Linanthastrum*.

HABIT annual; calyx either as in No. 1 or No. 2, but scarious junction-membranes more or less broad .....3. *Linanthus*, sens. lat.

PHYLLOTAXY opposite only at the lowest nodes; leaf-cutting of a pinnate pattern, or the leaves entire in a few slender annuals; calyx lacking conspicuous angles .....GILIA Subtribe.

In preparing the above key, an effort has been made to describe the features more accurately than is usually done; for example, the common contrast of leaves "opposite" vs. "alternate" is too generalized, the real difference consisting in the level of the change from opposite to alternate phyllotaxy.

1 Bartonia No. 20:14, 1940.

2 Amer. Midl. Nat. 27:741 1942; 31:211, 216, 230, 1944.



The first genus here accepted was proposed in 1840 by Hooker and Arnott,<sup>1</sup> then a few years later reduced to a section of *Gilia* by Bentham.<sup>2</sup> While the latter procedure has been widely followed, notable dissenters have been Nuttall,<sup>3</sup> Rydberg,<sup>4</sup> and Heller.<sup>5</sup>

The second was considered a genus by Nuttall, on labels, but was first published as *Gilia* section *Siphonella* by Gray,<sup>6</sup> and has been kept under *Gilia* by many subsequent workers. Its transfer to the segregate genus *Linanthus* was proposed by Greene in ms., as recorded by Milliken.<sup>7</sup> On the other hand, Rydberg<sup>4</sup> not only lumped it with the decidedly dissimilar *Leptodactylon*, but gave its feature of (essential) lack of scarious junction-membranes as diagnostic for that genus. *Siphonella* was published in Nuttall's sense by Heller<sup>8</sup> in 1912, but had meanwhile been used for a genus in the *Valerianaceae* by Small in 1903, so the Polemoniaceous genus is to be known as *Linantheastrum* Ewan.<sup>9</sup>

*Linanthus* was proposed as a genus by Bentham<sup>10</sup> in 1833, then was reduced to a section of *Gilia* by Endlicher<sup>11</sup> seven years later. Subsequent workers have been about equally divided as to which plan to follow. The view here favored is that Bentham's *Linanthus*, *Leptosiphon*, *Fenzlia*, and § *Dactylophyllum*, whether separated or not, are all wholly distinct from *Gilia*.

Taxonomists who lump all of these groups with *Gilia* state or imply that they do so because of the existence of intermediates. For precisely the same reason Kuntze<sup>12</sup> started to reduce practically the whole family *Polemoniaceae* to the single genus *Polemonium*. Actually, however, when adequate diagnostic procedures are employed, the number of real intermediates is so small as to be negligible. The mere fact that a few highly specialized *Leptodactylons* have their leaves pinnately dissected (instead of palmately) does not signify that they are intergrading with *Gilia*; it is simply a matter of parallel development of similar features along independent evolutionary lines. According to the viewpoint here adopted, segregate genera are acceptable whenever they exhibit apparently fundamental differentiating characters which prove to correlate in a reasonable number of cases.

In now listing and interpreting the epithets which have been proposed for members of the genus *Leptodactylon*, the same procedures as in the writer's previous papers are followed. New names and combinations are placed in bold-face type, accepted earlier names in italic, and discarded ones in light-face roman. Species and infra-specific epithets are uniformly decapitalized. Brand's Monograph in Engler's *Pflanzenreich* IV:250 is abbreviated to "Pol."

1 Bot. Beechey's Voy. pt. 8: 369, pl. 89, 1840.

2 In DC. Prodr. 9:316, 1845.

3 J. Acad. Nat. Sci. Phila. (2) 1:157, 1848.

4 Bull. Torr. Bot. Club 33:149, 1906.

5 Muhlenbergia 1:145, 1906.

6 Proc. Amer. Acad. Arts Sci. 8:267, 1870.

7 Univ. Calif. Publ. Bot. 2:54, 1904.

8 Muhlenbergia 8:57, 1912.

9 J. Wash. Acad. Sci. 32:138, 1942.

10 In Edw. Bot. Reg. 19: pl. 1622, p. 2, 1833.

11 Gen. Pl.: 657, 1840.

12 Rev. Gen. Pl. 3(2):202, 1898.

## Leptodactylon

- (a.) "*Gilia floribunda* var. *arida*" Jones, Proc. Calif. Acad. Sci. (2)5:713, 1895. Differing only in compact habit, this may become: *Leptodactylon watsoni* (Gray) Rydb., f. *aridum* (Jones) Wherry, stat. nov.
- "*brevifolium*" Rydberg, Bull. Torr. Bot. Club 40:474, 1913. Being merely a short-leaved, more or less glandular variant, this is here made *Leptodactylon pungens brevifolium* (Rydb.) Wherry, stat. nov.
- caespitosum* Nuttall, J. Acad. Nat. Sci. Phila. (2):157, 1848; "*Gilia pungens* var. c." Gray, Proc. Amer. Acad. Arts Sci. 8:268, 1870; "G. c." Nelson, Bull. Torr. Bot. Club 25:546, 1998, not G. c. Gray, Proc. Amer. Acad. Arts Sci. 12:80, 1875; "G. *pungens eupungens* var. c." Brand, Pol. :126, 1907, as to epithet but not as to entity. Very distinct.
- californicum* Hooker & Arnott, Bot. Beechey's Voy. pt. 8:369, pl. 89, 1840; "*Gilia* c." Bentham, in DC. Prodr. 9:316, 1845; "*Navarretia* c." Kuntze, Rev. Gen. Pl. 1/2:433; 1891. The type of the genus *Leptodactylon*.
- (d.) "*Gilia* *pungens* var. *devestita*" Brand, Pol.: 126, 1907, a substitute for "*Cantua* p. var. *squarrosa*" Howell, Fl. NW. Amer. 1, fasc. 4:453, 1901, mistakenly supposed by Brand to differ from "G. p. var. s." Gray.
- (e.) "*Gilia* *pungens* eu-*pungens*" Brand, Pol. :126, 1907; altered to *L. pungens eupungens* (Brand) Wherry, comb. nov. The original entity.
- (gla.) "*Gilia californica* very viscid form" Milliken, Univ. Calif. Publ. Bot. 2:41, 1904; "G. c. var. *glandulosum*" Eastwood, Bot. Gaz. 37: 447, 1904; "*Leptodactylon* c. g." Abrams, Bull. N. Y. Bot. Gard. 6:438, 1910. Differing merely in having the crowded leaves copiously glandular-arachnoid, this may become: *L. californicum* f. *glandulosum* (Eastw.) Wherry, stat. nov.
- gloriosum* (Brandegee) Wherry, comb. nov. "*Gilia* g." Brandegee, Proc. Calif. Acad. Sci. (2) 2:184, pl. 9, 1889. A remarkable species.
- hallii* (Parish) Heller, Muhlenbergia 1:146, 1906; "*Gilia* h." Parish, Erythraea 7:94, 1899; "G. *pungens* var. h." Milliken, Univ. Calif. Publ. Bot. 2:42, 1904; "G. p. h." Brand, Pol.: 128, 1907; "L. p. var. h." Jepson, Man. Fl. Pl. Calif. :807, 1925. Species status acceptable.
- "*hazela*" Peck, Proc. Biol. Soc. Wash. 49: 111, 1936. A large-flowered form, with corolla 25 mm. long, this is here made: *Leptodactylon pungens hookeri* f. *hazela* (Peck) Wherry, stat. nov.
- (ho.) "*Phlox hookeri*" Douglas ex Hooker, Fl. Bor. Amer. 2, pt. 8: 73, pl. 159, 1838; "*Gilia* h." Bentham in DC. Prodr. 9:316, 1845; "G. *pungens* var. h." Gray, Proc. Amer. Acad. Arts Sci. 8:268, 1870; "*Cantua* p. var. h." Howell, Fl. NW. Amer. 1, fasc. 4:453, 1901; "*Leptodactylon* p. var. h." Jepson, Man. Fl. Pl. Calif. :807, 1925; (and, invalid, "L. h." Nuttall, J. Acad. Nat. Sci. Phila. (2) 1:157, 1848; Rydberg, Bull. Torr. Bot. Club 40:474, 1913). Differing in being glandular and having a distinct range, this should become *Leptodactylon pungens hookeri* (Dougl. ex Hook.) Wherry, stat. nov.

- jaegeri* (Munz) Wherry, comb. nov. "Gilia j." Munz, Bull. S. Calif. Acad. Sci. 31: 68, 1932; "*L. pungens* synonym" Jepson, Fl. Calif. 3(2): 143, 1943. Acceptable as a species.
- lilacinum* Greene (in Baker, W. Amer. Pl. 1:18, 1902, nom. nud.) ex Brand, Pol. :128, fig. 27, 1907; "Gilia l." Brand, loc. cit. The earliest name for a common Cascade-Sierran species. Brand's text and plate do not agree, however, as to leaf-characters, while his diagnostic features, calyx-membranes "horizontally truncate" and corolla "lilac" lack significance.
- "*patens*" Heller, Muhlenbergia 1:146, 1906, as a substitute for "*Gilia pungens* var. *squarrosa*" Gray, Proc. Amer. Acad. Arts Sci. 8:267, 1870. This entity is not here regarded as a species, so "*patens*" is superfluous.
- (pul.) "*Gilia pungens pulchriflora*" Brand, Ann. Cons. Jard. Geneve 15/16 :333, 1916. This was founded on a collection by Culbertson of what is here regarded as a mere large-flowered form, hence the novelty: *Leptodactylon lilacinum* f. *pulchriflorum* (Brand) Wherry, stat. nov.
- pungens* (Torrey) Rydberg Fl. Colo.: 279, 1906; "*Cantua* ? *pungens*" Torrey, Ann. Lyc. Nat. Hist. N. Y. 2:221, 1828; "*Batanthes* p." Rafinesque, Atl. J. 1, No. 4:145, 1832; "*Aegochloa* ? *torreyi*" Don, Gen. Syst. Dichl. Pl. 4:246, 1838 (misprinted "*Ogochloa*" by Hooker, Curt. Bot. Mag. 81: pl. 4872, 1855); "*Gilia* p." Benthams, in DC. Prodr. 9:316, 1845, not "*G. p.*" Douglas ex Hooker, Curt. Bot. Mag. 57: pl. 2977, 1830; "*L. p.* of Torrey" Nuttall, J. Acad. Nat. Sci. Phila. (2) 1:157, 1848, combination not formally made. A widespread species divisible into several subspecies.
- (sh.) "*L. pungens* var. *shastense*" Jepson, Fl. Calif. 3(2):143, 1943. Differing only in having mostly opposite leaves, this is here made *Leptodactylon lilacinum* f. *shastense* (Jeps.) Wherry, stat. et comb. nov.
- (sq.) "*Gilia pungens* var. *squarrosa*" Gray, Proc. Amer. Acad. Arts Sci. 8:268, 1870; "*Cantua* p. var. s." Howell, Fl. NW. Amer. 1, fasc. 4:453, 1901; "*L. patens*" Heller, Muhlenbergia 1:146, 1906; "*G. p.* ssp. *eupungens* var. *devestita*" Brand, Pol. :128, 1907; *L. pungens squarrosus* Tidestrom, Proc. Biol. Soc. Wash. 48:42, 1935, the last acceptable.
- (su.) "*L. pungens* var. *subflavidum*" Jepson, Fl. Calif. 3(2):143, 1943. Differing from the original form of another species only in the leaves being mostly alternate, this is here made: *L. hallii* f. *subflavidum* (Jeps.) Wherry, stat. et comb. nov.
- tenuilobum* (Parish) Heller, Muhlenbergia 1:146, 1906; "*Gilia t.*" Parish, Erythea 7:95, 1899; "*G. pungens* var. *t.*" Milliken, Univ. Calif. Publ. Bot. 2:42, 1904; "*L. p.* var. *t.*" Jepson, Man. Fl. Calif. :807, 1925. Regarded as deserving species rank.
- veatchii* (Parry ex Greene) Wherry, comb. nov. "*Gilia v.*" Parry ex Greene, Bull. Calif. Acad. Sci. 1:198, 1885. A well-marked species.
- watsoni* (Gray) Rydberg, Bull. Torr. Bot. Club 33:149, 1906; "*Gilia w.*" Gray, Proc. Amer. Acad. Arts Sci. 8:267, 1870. A good *Leptodactylon*.

## LEPTODACTYLON: KEY TO SPECIES AND SUBSPECIES

- PLANT a moderate-sized shrub; corolla pink to white, salverform, about 25 mm. across; filaments adnate to the tube  $1\frac{1}{3}$  -  $1\frac{1}{2}$  their length.  
 LEAF-DISSECTION palmate; stamens included; sw. Calif. .... *L. californicum*.  
 LEAF-DISSECTION pinnate; stamens exserted; Baja Calif. .... *L. gloriosum*.
- PLANT an under-shrub; corolla white, yellow, or pink, often suffused with purple, funnel-salverform; filaments sub-completely adnate to tube.  
 HABIT prostrate; leaves imbricate throughout, sub-acerose; floral parts numbering resp. 4, 4, 4, 2; Nev. - w. Nebr. .... *L. caespitosum*.  
 HABIT upstanding; only axillary leaves imbricate; leaves more or less acerose; floral parts numbering resp. 5, 5, 5, 3 (except in mutants).  
 COSTAE of sepals and bracts obscurely laminar-bordered *L. pungens*; ssp.:  
 PRINCIPAL LEAVES 5 - 7 mm. long; e. Wash. - N. M. .... *brevifolium*.  
 PRINCIPAL LEAVES 7.5 - 15 mm. long.  
 MIDDLE LEAF-LOBE 2  $\times$  the next outer, patent or reflexed; e. Ore.  
 - Utah, southw. grading to *L. hallii* .... *squarrosus*.  
 MIDDLE LEAF-LOBE  $1\frac{1}{4}$  -  $1\frac{1}{2}$   $\times$  next outer, ascending-spreading.  
 PUBESCENCE copious, conspicuously glandular; corolla 18 - 25 mm. long (f. *hazela*); Wash. - n. Calif., southw. grading to *L. lilacinum* .... *hookeri*.  
 PUBESCENCE sparse, eglandular or minutely glandular; corolla 12 - 20 mm. long; e. Wash. - w. Nebr. .... *cupungens*.
- COSTAE of sepals and bracts distinctly laminar-bordered.  
 LEAVES mostly pinnate, opposite, crowded, rigid and glandular; plant dwarf; s. Calif.; grading to *L. veatchii* .... *jaegeri*.  
 LEAVES palmate, pedate, or the upper pinnate.  
 LEAF-POSITION opposite throughout; leaves palmately to pedately parted into subequal lobes to 15 mm. long, lax to firm (f. *aridum*); pubescence sparse; s. Ida. - w. Colo. .... *L. watsoni*.  
 LEAF-POSITION varying from opposite to alternate; leaf-parting palmate, pedate, or, toward inflorescence, pinnate.  
 WOODY TISSUE well-developed; leaves coarse, glandular, many subopposite to opposite; Baja Calif. .... *L. veatchii*.  
 WOODY TISSUE moderately developed; glandularity variable.  
 LEAF-LOBES 7 - 3, the middle about  $1\frac{1}{2}$   $\times$  the next outer, opposite only below or well up stem (f. *shastense*); corolla 18 - 27 mm. lg. (f. *pulchriflorum*); Ore. - Calif. .... *L. lilacinum*.  
 LEAF-LOBES 5 - 1, the middle 2 - 4  $\times$  the next outer.  
 BRACTS short-pinnate; leaves opposite well up stem or only below (f. *subflavidum*); corolla 12 - 25 mm. long, the petal-blades oblanceolate; s. Calif. - Nev. .... *L. hallii*.  
 BRACTS elongate-pinnate; corolla 20 - 25 mm. long, the petal-blades linear; s. Calif. .... *L. tenuilobum*.

## Linanthastrum

(a.) "*Gilia floribunda* var. *arida*" Jones, Proc. Calif. Acad. Sci. (2) 5:713, 1895, has the leaves pedately parted into acerose divisions and the calyx "very hyaline between the angles," so is a *Leptodactylon*. It was referred above to *L. watsoni*.

**floribundum** (Gray) Wherry, comb. nov. "*Gilia* f." Gray, Proc. Amer. Acad. Arts Sci. 8:267, 1870; "*Navarretia* f." Kuntze, Rev. Gen. Pl. 1/2: 433, 1891; "*Linanthus* f." Greene ex Milliken, Univ. Calif. Publ. Bot. 2:55, 1904; "*G. nuttallii* var. *parviflora* subvar. f." Brand, Pol.: 125, 1907; "*Leptodactylon nuttallii* var. f." Jepson, Man. Fl. Pl. Calif.: 808, 1925; "*L. f.*" Tidestrom, Proc. Biol. Soc. Wash. 48:42, 1935; "*G. n.* var. f." Munz, Man. S. Calif. Bot.: 399, 1935; *Linanthus n.* var. f." McMinn, Man. Calif. Shrubs: 446, 1939; "*Linanthastrum n.* ssp. f." Ewan, J. Wash. Acad. Sci. 32:141, 1942; "*Siphonella* f." Jepson, Fl. Calif. 3 (2): 218, 1943. This represents an extreme development of tendencies shown in what is below termed form *a* of *L. nuttallii*, toward tall stature, narrow leaf-lobes, and pedicellate flowers. It is as good a species as many in the *Polemoniaceae*. The typical form has the leaves mostly several-lobed; a variant with them reduced to single lobes, "*S. f.* var. *hallii*" Jepson, Fl. Calif. (3) 2:219, 1943, is preferably classed as *Linanthastrum floribundum* f. *hallii* (Jeps.) Wherry, stat. nov.

**melingii** (Wiggins) Wherry, comb. nov. "*Leptodactylon m.*" Wiggins, Contr. Dudley Herb. 1:173, pl. 14 & 16, 1933. This is the extreme foreshadowed in form *d* of *L. nuttallii*, toward low stature, dense pubescence, and small flowers.

**nuttallii** (Gray) Ewan, J. Wash. Acad. Sci. 32:138, 1942. "*Siphonella montana*" and "*S. parviflora*" Nutt. ex Gray as synonyms of "*Gilia n.*" Gray, Proc. Amer. Acad. Arts Sci. 8:267, 1870; "*Navarretia n.*" Kuntze, Rev. Gen. Pl. 1/2: 433, 1891; "*Linanthus n.*" Greene ex Milliken, Univ. Calif. Publ. Bot. 2:54, 1904; "*Leptodactylon n.*" Rydberg, Bull. Torr. Bot. Club 33:149, 1906; "*Siphonella n.*" Heller, Muhlenbergia 8:57. 1912. The type of the genus. Highly variable, the following forms being noteworthy: (*a*) tall glabrate ("*G. n.* var. *montana*" Brand, Pol.: 125, 1907); height 20-30 cm., nodes remote, length of leaf-lobes 15-25, calyx 7-9, and corolla 12-18 mm. (*b*) medium glabrate ("*S. montana*" Nutt. ex Gray, loc. cit., first synonym cited so taken as the typical form; "*G. n.* var. *parviflora*" Brand, loc. cit., who by "upper leaves linear-lanceolate" meant lobes linear-ob lanceolate); height 12-18 cm., nodes subremote, length of leaf-lobes 10-15, calyx 6-8, and corolla 9-15 mm. (*c*) dwarf glabrate: height 8-12 cm., nodes crowded, length of leaf-lobes 8-10, calyx 5-6, and corolla 8-10 mm. And (*d*) medium pubescent ("*S. parviflora*" Nutt. ex Gray, loc. cit.): like *b* except that the foliage is covered with short hairs.

(s.) "*Linanthus saxiphilus*" A. Davidson, Bull. S. Calif. Acad. Sci. 19:10, 1920; "*Siphonella nuttallii* synonym" Jepson, Fl. Calif. 3 (2):218, 1943. This entity differs only in the pubescent herbage, so may become: *Linanthastrum floribundum* f. *saxiphilum* (A. Dav.) Wherry, stat. nov.

## LINANTHASTRUM: KEY TO SPECIES

LEAVES 7- to 3-lobed, rather soft; flowers numerous; pedicels 0-2 (5) mm.  
long; Wash. - Wyo. & n. Mex. .... *L. nuttallii*.

LEAVES (5-) 3- to 1-lobed, rather firm; flowers sparse.

HEIGHT 20-50 cm.; herbage glabrate to pubescent (f. *saxiphilum*); leaf-lobes narrow-linear, 12-25 mm., pedicels (1) 5-20 mm., and corolla 10-20 mm. long; c. Calif. - Colo. & n. Mex. .... *L. floribundum*.

HEIGHT 10-15 cm.; herbage dense-pubescent; leaf-lobes broad-linear, 5-10 mm., pedicels 0-1 mm., and corolla 10 mm. long; Inyo Co., Calif. - Baja Calif. .... *L. melingii*.

Relationships of *Linanthastrum*.—When the writer first saw *L. nuttallii* in the field, in Idaho during 1931, he took it to be a *Linanthus*, and for a time remained favorable to that view, which had indeed been urged by Greene and others. If the genus *Linanthus* is interpreted in a comprehensive sense, as including some 50 species of various aspect distributed among 5 subgenera, then the *Linanthastrum* assemblage, the only diagnostic character of which is its perennial duration, should be made just another subgenus. It would, to be sure, belong nowhere near the subgenus *Eulinanthus*, which has a *Leptodactylon* type of calyx; but it would fit in well between the subgenera *Dactylophyllum* and *Pacificus* as defined by Jepson in Fl. Calif. 3 (2): 200, 1943. If on the other hand *Linanthus* sens. lat. is split into several genera (as done by Bentham when he first studied them), then *Linanthastrum* may well be classed as an independent genus, characterized by perennial duration and broad sepals with a minimum of intersepaline membranes. This is the viewpoint taken here.

As a synonym of his "*Gilia nuttallii* var. *parviflora*," Brand, Pol.: 125, 1907, mistakenly gave "*Gilia laxa*" Vasey & Rose, Proc. U. S. Nat. Mus. 11:531, 1889. These authors observed how close this entity is to what they, following Gray, treated as *Gilia* Section *Siphonella*. Its characters show it to be indeed a reduced annual derivative of *Linanthastrum floribundum*. Since, however, difference in duration is here accepted for the basis of separating genera, it fits into the genus *Linanthus* sens. lat. A new combination is accordingly called for: *Linanthus laxus* (Vasey & Rose) Wherry, comb. nov.



## Annual Phlox Species

Eula Whitehouse\*

In the course of a study of the annual *Phlox* species<sup>1</sup> several new entities had to be described and several new combinations made. It is the purpose of this paper to place these on record.

With the description of *Phlox Drummondii* by Hooker (1835) the first annual *Phlox* was recognized. Previous to the collection of Drummond's specimens in Southeast Texas in 1834, Berlandier collected annual *Phlox* plants in several localities in South Texas; but they were not identified with this group until many years later. Since that time several other species and varieties of annuals have been described, the history of which will be taken up under the discussion of each recognized species. *Phlox Drummondii* is the only annual *Phlox* known in horticulture, but it has gained a place of primary importance as a garden annual throughout the world.

The inclusion of annual plants in a group long known for their perennial growth necessitated the addition or change of certain characteristics for the genus. The outstanding differences common to all the annuals are the alternate arrangement of leaves and branches of the upper part of the plant and the brief period required for the germination of the seeds.

All the annual species of *Phlox* have their native habitat in Texas east of the Pecos River. Their distribution is almost confined to the central region of the state, but two species have migrated a short distance beyond the state boundaries. A single collection of *P. cuspidata* is known from the southern part of Oklahoma. It is probably to be found in western Louisiana as it is known from Orange, Texas, just across the border. Berlandier (2526 ANS) reports that *Phlox glabriflora* is found in sandy places from Matamoras, Mexico, to the mouth of the Nueces River in Texas.

It is interesting to note that the distribution of each species is apparently limited by the particular formation on which it occurs. This seems to point to the fact that the variations in this group of *Phlox* have largely resulted from changes in the soil. These terraces and formations usually occur in narrow strips extending from northeast to southwest.

The common characteristic of all the annual species is the cymose branching or monopodial growth of the stem. This is a feature of many western perennials, but it is less frequently found in the eastern perennials. No perennial species are known for hundreds of miles west of the western limit of distribution of the annual species, but two perennial species, *Phlox villosissima* and *P. pilosa* var. *aspera*, occur in scattered places through the same region as that occupied by *P. Roemeriana* and *P. McAllisteri*. Of the living perennials,

\* Now at the Lundell Herbarium of Southern Methodist University, Dallas, Texas.

1 For a more extended discussion of the taxonomy and anatomy of these species see "A Study of the Annual *Phlox* Species," thesis presented to the Graduate School of the University of Texas, 266 pages, manuscript, 1939.

it may be said that *P. villosissima* bears the closest relationship to the annuals; that the relationship between this and the annual species is very close is attested by the fact that for nearly fifty years it passed as a variety of *P. Drummondii*.

Grateful acknowledgement is made to the many people who have assisted in the collection of specimens and the checking of distribution; to Dr. E. T. Wherry for his distributional notes and reprints; to Dr. B. C. Tharp for his extensive collections, assistance in borrowing material, and especially for his field work in 1931 and 1934 in checking distribution; and to Dr. F. McAllister, for his valuable help and criticism.

Appreciation is also extended to the curators of the various herbaria who have assisted with the loan of material. The following list includes the herbaria from which specimens were borrowed and the abbreviations used in referring to them:

|  |   |
|--|---|
| ANS—Academy of Natural Sciences of Philadelphia. | ND—Nieuwland Herbarium, Notre Dame.     |
| B—Brooklyn Botanical Garden.                     | NT—North Texas State Teacher's College. |
| BIM—Instituto de Biología de México.             | NY—New York Botanical Garden.           |
| C—University of California, Berkeley.            | RM—Rocky Mountain Herbarium.            |
| F—Field Museum of Natural History.               | T—University of Texas.                  |
| G—Gray Herbarium of Harvard University.          | US—United States National Herbarium.    |
| M—Missouri Botanical Garden.                     | USDA—National Arboretum Herbarium.      |

## KEY TO THE ANNUAL SPECIES OF PHLOX

- A. Ovules in carpel 5; seeds irregular; lower leaves spatulate; calyx as long as glabrous corolla tube; corolla purple-pink, eye with white laterals and inner rim of yellow, throat nearly black.....8. *P. Roemeriana*
- AA. Ovules in carpel 1; seeds regular; calyx much shorter than corolla tube; eye of corolla with no yellow.
  - a. Lower leaves oblanceolate or spatulate, length less than seven times the width, apex acute or lanceolate.
    - b. Lower leaves oblanceolate, upper leaves oblong or lanceolate, usually wider than the lower; corolla red or purple, lobes nearly as wide as long.
    - c. Leaves thick, pubescence hispid, corolla mostly red.
      - d. Corolla a brilliant red.....1. *P. Drummondii*
      - e. Throat cream, leaves acute, 8-12 mm. wide and 3.5-6 cm. long.....1a. *P. D. var. typica*
      - ee. Throat dark red.
        - f. Leaves acute, 8-12 mm. wide, 4-6 cm. long.....1a. *P. D. var. instabilis*
        - ff. Leaves lanceolate, 4-7 mm. wide, 2.5-4 cm. long.....1c. *P. D. var. Wilcoxiana*
    - dd. Corolla vari-colored. Mostly cultivated hybrids.<sup>2</sup>

<sup>2</sup> The following key to varieties which have arisen in cultivation includes only those varieties which are distinguished by characters other than the color and size of the corolla. The author has not seen plants of several of these varieties, basing her findings on discussions given by Kelly (Kelly, J. P. *Journ. N. Y. Bot. Gard.* 16:179-191. 1915; *ibid.* 18:83-86. 1917; *Gen.* 5:189-248. 1920.) and on Grieve's original description.

1 Flower clusters rounded, dense; plants semi-dwarf; flowers small.

*P. D. var. hortensiaeflora* Hort., *Gartenfl.* 1882.

1 Flower clusters normal, nearly flat-topped.

2 Corolla funnellform, rose, white-striped.

*P. D. var. Radowitzii* Regel, *Gartenfl.* 225. 1865.

2 Corolla not funnellform.

- cc. Leaves thin, pubescence soft; corolla purple.  
 d. Eye of corolla with white laterals, mature pedicels about 4 mm. long.....2. *P. McAllisteri*  
 dd. Eye of corolla a red star, mature pedicels 5-12 mm. long.....3. *P. Goldsmithii*  
 bb. Lower leaves spatulate, apex acute, upper leaves linear, narrower than lower; corolla purple, lobes more than  $1\frac{1}{2}$  times as long as wide.....4. *P. cuspidata*  
 c. Leaves 25-30 mm. long, 3.5-6 mm. wide; corolla tube 10-12 mm. long.  
 d. Corolla lobes 6-7 mm. long and 3-4 mm. wide.....4a. *P. c. var. typica*  
 dd. Corolla lobes 9-11 mm. long and 6 mm. wide.....4b. *P. c. var. grandiflora*  
 cc. Leaves 15-24 mm. long, 2-3 mm. wide; corolla tube 8-9 mm. long, lobe 5-6 mm. long and 2.5-3 mm. wide.....4c. *P. c. var. humilis*  
 aa. Lower leaves linear-oblancoate, thin, apex acuminate, length more than seven times the width; corolla purple.  
 b. Corolla tube 15-17 mm. long, pubescent, eye a red star; lower leaves 3-6 cm. long.....5. *P. Tharpui*  
 bb. Corolla tube 10-14 mm. long; eye with white laterals.  
 c. Corolla tube pubescent, eye with short red laterals; lower leaves less than 5 cm. long.....6. *P. littoralis*  
 cc. Corolla tube usually glabrous, eye without short red laterals, lower leaves more than 5 cm. long.....7. *P. glabriflora*

1. *PHLOX DRUMMONDII* Hooker, Bot. Mag. IX n.s., t. 3441. 1835.<sup>3</sup>

1a. *Phlox Drummondii* var. *typica* Whitehouse, var. nov.

Annual, ramis inferioribus divaricatis; foliis 3-6 cm. longis; floribus cymosis, corollae tubo 15-17 mm. longo, lobis 12-15 mm. longis et 12 mm. latis, rubris, oculo atque faucibus ruberrimis.

Central stem 10-30 or more cm. high, basal branches opposite, divaricate-ascending to height of main stem; upper branches alternate, obliquely ascending; lower leaves 3-6 cm. long and 8-12 mm. wide; thick and glutinous to viscid, hispid-pubescent above; bracts oblong, broad-based, with acute or acuminate apex, 22 mm. long and 8 mm. wide; bracteoles 10-15 mm. long, linear to lanceolate; inflorescence densely cymose with 2-3 primary peduncles, 7-70 mm. long, the terminal shorter; secondary peduncles very short, 1-3 mm. long; pedicels very slender, 2-7 mm. long; terminal and second peduncle commonly 4-flowered, third 12-flowered, all reaching about same height at time of flowering but terminal clusters shorter at maturity of capsules; calyx 8-12 mm. long; lobes subterete, awns slender, 1-5 mm. long; midnerve not prominent; corolla tube usually glandular, 15-17 mm. long, constricted 3-4 mm. above the base; throat about 1 mm. deep, within pale cream; limb 25-35 mm. broad, lobes 12-15 mm. long and 12 mm. wide, pale beneath and a brilliant crimson above

3 Plants dwarf and bushy; leaves small; flowers small, scarlet.

*P. D.* var. *Heynholdii* (Grieve) Whitehouse n. comb.  
 (*P. Heynholdii* Grieve, Gard. Chron. 1041. 1871.)

3 Plants not dwarf; foliage normal.

4 Corolla lobes ruffled; corolla small; style lacking.

*P. D.* var. *astylis* Kelly, Gen. 5:189-248. 1920.

4 Corolla lobes not ruffled.

5 Corolla lobes toothed or fringed.

*P. D.* var. *cuspidata* Wittmack, Gartenfl. 37:1, t. 1264. 1888.

5 Corolla lobes acute.

*P. D.* var. *radiata* Benary, Gartenfl. 52:27. 1903.

<sup>3</sup> For the sake of brevity, complete bibliography, descriptions, and citation of specimens are given here only in the case of new entities. (See also footnote 1.)

with a deeper crimson eye; anthers 2.5 mm. long, filaments of different lengths; pistil about 4 mm. long; ovary ovate, 1.5 mm. long, style slender 1 mm. long; stigmas 3, 1.5 mm. long, very narrow; capsule 3-4 mm. high; seed 3, dark brown, roughly rugose and deeply furrowed, broadly elliptical.

*Distribution*.—Southeast-Central Texas, in sandy soil of the post oak belt between the Brazos and San Antonio Rivers.

*Specimens examined*.<sup>4</sup>—TEXAS: AUSTIN COUNTY: San Felipe, 1934, *Drummond* 197, 5 313(G); BASTROP COUNTY: Smithville, Apr. 1933, *Pilsbry* (ANS); Apr. 20, 1934, *Whitehouse* 530 (T); COLORADO COUNTY: Columbus, Apr. 8, 1907, *Howell* (US); Apr. 20, 1934, *Whitehouse* 526 (B, BIM, ND, USDA<sup>3</sup> and 526a (G, M, NY, US); DE WITT COUNTY: Cuero, Apr. 24, 1899, *Bray* (T, US); May 3, 1898, *Marlatt* (US); Mar. 15 (NY, T) & Apr. 18, 1931, *Tharp* (T); Feb. 28, 1938 & Mar. 26, 1936, *Whitehouse* (US); FAYETTE COUNTY: La Grange-Smithville, May 11, 1935, *Moebus* (T); Mar. 24, 1931, *Tharp* (T); GOLIAD COUNTY: Goliad, Feb. 1927, *Williams* (ANS, T); Goliad-Refugio, Apr. 2, 1934, *Whitehouse* 524 (G, M, RM); GONZALES COUNTY: Waelder, Mar. 31, 1934, *Whitehouse* 215c (ANS, NY, US); JACKSON COUNTY: Hallettsville, July 4, 1921, *Fisher* (US); Morales-Lavaca, May 12, 1934, *Whitehouse* 525a (ANS, C, F, G, M); north of Edna, 1932, *Drushel* (T); VICTORIA COUNTY: Victoria-Cuero, Mar. 15, 1931 & May 25, 1930, *Tharp* (T); WALLER COUNTY: Bellville, Apr. 1936, *Whitehouse* (T); WASHINGTON COUNTY: southeast of Brenham, Apr. 1936, *Whitehouse* (T).

Some specimens indicate hybridization between *P. cuspidata* and *P. Goldsmithii*.

#### 1b. *Phlox Drummondii* var. *instabilis* Whitehouse, var. nov.

Radix annua, caulis 1-3 dm. alta, ramosa, foliis variis, 3-5 cm. longis et 4-8 mm. latis, apice plus minusve acutis; calyce 8-9 mm. longo, corollae lobis 10-11x8 mm. diam., rubris, faucibus atri-rubentibus, oculo atri-fusco.

Root annual; stem 1-3 dm. high, commonly branched; leaves very variable, lower 3-5 cm. long and 4-8 mm. wide; alternate leaves oblong, 3-4 cm. long and 6-10 mm. wide, apex acute to acuminate, bracts oblong-lanceolate with rounded or semi-clasping bases; inflorescence clusters dense, flat-topped, 3 peduncles, the terminal and second 4-flowered, the third with 12 or more flowers; pedicels 4-7 mm.; calyx 8-9 mm. long in flower, 10-11 in fruit; corolla lobes 10-11 x 8 mm., limb 20-22 mm. broad, brilliant red, eye slightly darker, and throat dark.

*Distribution*.—Bastrop, Brazos, and Burleson Counties, Texas.

*Specimens examined*.—TEXAS: BASTROP COUNTY: Bastrop, 1928, *Duval* 195 (T); Apr. 17, 1928, *Palmer* 33374 (G, N, M); Mar. 1921, *Tharp* (1702) (T); Apr. 8, 1923, *Tharp* 1959 (T); Apr. 6, 1926, *Tharp* (T); Mar. 31, 1934, *Whitehouse* 531 (T); Smithville, Mar. 17, 1930, *Marrs* (T); Apr. 20, 1934, *Whitehouse* 210 (C, F, ND, NY, T, US TYPE); BRAZOS COUNTY: near Bryan, Apr. 1934, *McAllister* (T); Apr. 21, 1934, *Lehmann* (T); BURLESON COUNTY: Lyons, Apr. 1928, *Giesenschlag* (T).

The plants grouped in this variety show many variations, especially in regard to size and in length and width of leaves. The red color seems to be stable throughout most of its range except in plants growing in close proximity

<sup>4</sup> This list includes specimens from the native habitat and does not include those specimens considered as cultivated escapes.

<sup>5</sup> Type in Kew Herbarium.

to *Phlox cuspidata* and there such plants show characteristics intermediate between plants of this variety and those of that species.

1c. *Phlox Drummondii* var. *Wilcoxiana* n. comb.

*Phlox Wilcoxiana* Bogusch, *Torreyia* 29:135. 1929.

Root annual; stem 1-5 dm. tall, usually erect, sometimes branched at the base but alternate branches usually better developed; lower leaves opposite, oblanceolate with narrowed bases, petioled, 2.5-4 cm. long and about 6 mm. wide, apex acuminate; alternate leaves linear-lanceolate, 2-4.5 cm. long, 4-8 mm. wide; inflorescence clusters usually rounded and of two primary peduncles, terminal 2-4-flowered, second 2-6-flowered and twice the length of the first; pedicels 5-7 mm. long; calyx 7-9 mm. long in flower, lobes subulate, aristate; corolla brilliant red, eye slightly darker, and throat dark, limb 25 mm. or more broad, lobes usually not quite touching, apex apiculate.

*Distribution*.—Caldwell, Gonzales, and Guadalupe Counties, Texas.



Map A.—Distribution of four of the annual species of *Phlox*. 1. *P. cuspidata* Sheele. 2. *P. Drummondii* Hooker. 3. *glabriflora* (Brand) Whitehouse. 4. *P. littoralis* (Cory) Whitehouse.

*Specimens examined.*—TEXAS: CALDWELL COUNTY: 1931, McBryde (T); March 20, 1931, Mercer (T); Lockhart-Luling, Apr. 3, 1938, Whitehouse (T); GONZALES COUNTY: near Ottine, Feb. 14, 1926, Bogusch & Molby 2727 (H, University of Illinois Type); Red Hill, Feb. 7, 1926, Bogusch (T); northern part, Mar. 20, 1931, McBryde (T); May 31, 1928, Normand (T); Apr. 1924, Schulz (F); Apr. 18, 1931, Tharp (T); Ottine, Apr. 30, 1935, Whitehouse 570 (M) & Mar. 28, 1936 (C, T, US); northern part, Apr. 30, 1935, Whitehouse 302 (C, F, T, US) & Apr. 3, 1938 (T); GUADALUPE COUNTY: near Seguin, Mar. 28, 1935, Frenzel (T); Apr. 15, 1876, Joor 23 (B).

Although the type specimen lacks lower leaves, the leaves on plants of other collections from the same vicinity afford sufficient evidence to separate this as a new variety. They are proportionately longer and narrower than in var. *typica*. The flower clusters are more rounded and have fewer flowers. The corolla limb is unusually large on most specimens, and the throat is dark. Perhaps the most distinctive feature is the lanceolate apex of the leaf.

The greatest variation comes in the size of the corolla limb and the width of the lobes, this variety having the largest corollas and the narrowest lobes of any of the wild forms; however, overlapping lobes frequently occur. Occasionally the lower leaves are 5-6.6 cm. long and vary from very narrow to rather wide. The foliage has a tendency to dry with a yellow-green color. The pubescence is quite variable and often viscid, the hairs in general being softer than those of var. *typica*. The leaves are often almost glabrous, but plants growing in deep sand are densely villous, particularly on the inflorescence.

There seem to be four distinct forms of the variety. There is some indication of hybridization with *Phlox cuspidata* in Gonzales County.

## 2. *Phlox McAllisteri* Whitehouse, sp. nov.<sup>6</sup>

*Phlox Drummondii* Hooker, variety in Whitehouse, *Tex. Fl. Nat. Co.*, p. 107.

Radix annua; caulis 25-30 cm. altus, ramosus, pubescens; foliis inferioribus linearibus vel spatulatis, 4-5.5 cm. longis, 5-7 mm. latis, apice acutis vel acuminate, foliis alternis oblongis, sessilibus, apice acutis basique rotundatis, cymis densifloris, pedicellis 4-floriferis, calyce 10-14 cm. longo, glanduloso-pubescenti, laciniis lineari-acuminatis, aristatis, corollae tubo 12-13 mm. longo, glanduloso, lobis cuneatis, purpureis, basi albis, capsula ovoidea, tri-ovulata.

Root annual, small; stem 25-30 cm. high, rather stout, branched at base and at upper nodes, densely pubescent with long, soft eglandular hairs; the five lower pairs of leaves opposite, linear to broadly spatulate, apex commonly acuminate, the upper longer, 4-5.5 cm. long and 5-7 mm. wide; alternate leaves oblong, broader above the middle, sessile, apex acute to lanceolate, 3-4 cm. long and 7-12 mm. wide; bracts oblong-lanceolate, base sessile-rounded, 23-27 mm. long and 7-9 mm. wide; braceoles linear-acuminate 15-17 mm. long and 2 mm. wide; upper surface nearly glabrous, few long hairs on thickened margins and lower surface, leaves thin, inflorescence a dense cyme, pedicels elongating very little with maturity, commonly 2-4 mm. long; terminal cluster usually of 2-peduncle, each 4-flowered, with third and fourth peduncles often compound and blooming several weeks later; densely pubescent with long soft glandular hairs; calyx 10-14 mm. long, tube much shorter than the lobes, lobes

<sup>6</sup> The specific name honors Dr. Frederick McAllister, Professor of Botany of the University of Texas.

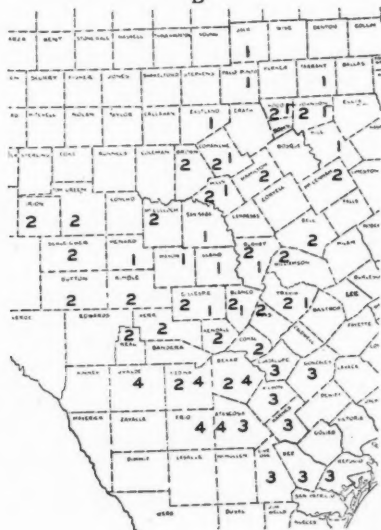


acuminate aristate, midnerve prominent, about  $\frac{2}{3}$  the length of calyx, densely pubescent with long and short glandular hairs; corolla tube 12-13 mm. long, densely glandular pubescent, sharply constricted 2.5 mm. above the base, not hairy within, throat dark purple within, pale and glabrous below, limb 20-22 mm. broad, lobes cuneate, apex rounded and mucronate, 10-11 mm. long and 8-10 mm. wide, light purple with two distinct lateral marks of white at the base of the lobe with often a slightly darker purple midnerve; pistil 3.75 mm. long, ovary 1.5 mm., ovoid, 3-ovuled, style dark green, slender, .75 mm. long, stigmas pale yellow, linear, 1.5 mm. long, disc prominently lobed; capsules 4 mm. long, globose-ovoid; seed 3, gray-brown, oblong, 3 x 1.5 mm., raphe narrow, rugae irregular-convolute.

*Distribution.*—In sandy soils of the Trinity Formation, commonly known as the cross-timbers region, North-Central, Texas.

*Specimens examined.*—TEXAS: BLANCO COUNTY: Johnson City-Fredericksburg, Apr. 20, 1934, Deveny (T); BURNET COUNTY: Burnet-Llano, Apr. 21, 1934, Deveny (T); April, 1892, Schaupp (B); Burnett-Marble Falls, April 13, 1930, Tharp (T); May, 1936, Whitehouse 584 (T); Apr. 16, 1930, Wolff 1562 (US); COMANCHE COUNTY: DeLeon, Apr. 28, 1934, Tharp (BIM, T); EASTLAND COUNTY: Carbon, May, 1931, Townsend (T); Comyn, Apr. 30, 1931, School (T); Rising Star, Apr. 16, 1931, Procter (T); GILLESPIE COUNTY: near Fredericksburg, Apr. 21, 1934, Deveny (F, M, T); Mar. 25, 1931, Tharp (T); June 7, 1929, Whitehouse (T); Fredericksburg, May 7, 1934, Whitehouse 514; JACK COUNTY: in post oak sand, May 9, 1931, Harris (NT); JOHNSON COUNTY: Cleburne-Parker, May 5, 1931, Whitehouse (T); HILL COUNTY: Apr. 1919, Bro. Anecl (US); HOOD COUNTY: Granbury, Apr. 16, 1930, Cooper (T); LLANO COUNTY: Apr. 21, 1934, Deveny (ANS, T); Aug. 1848, Lindheimer (M); Apr. 15, 1931, McKelvey 1862 (US); Enchanted Rock, Apr. 1928, Normand (T); Enchanted Rock, June 1, 1930, Tharp & Whitehouse (G, NY, T,

## B



Map B.—Distribution of four of the annual species of *Phlox*. 1. *P. McAllisteri* Whitehouse. 2. *P. Roe-meriana* Scheele. 3. *P. Goldsmithii* Whitehouse. 4. *P. Tharpii* Whitehouse.

US); Enchanted Rock, Apr. 25, 1931, *Tharp* (T); Apr. 18, 1931, *Whitehouse* 582 (ANS, C, F, G, M, ND, T, US TYPE); May 6, 1936, *Whitehouse* 585 (US); MASON COUNTY: Apr. 21, 1934, *Deveny* (T); Apr. 5, 1936, *Whitehouse* (T); MENARD COUNTY: Apr. 21, 1936, *Deveny* (T); MILLS COUNTY: Goldthwaite, Apr. 10, 1931, *Morgan* (T); PALO PINTO COUNTY: in post oak sand, June 20, 1927, *Harris* (NT); SAN SABA COUNTY: Apr. 1934, *Dobie* (T US); Cherokee, Apr. 30, 1931, *Norton* (T); TARRANT COUNTY: *Reverchon* 2150 (F); Ft. Worth-Waco, Apr. 3, 1931, *McKelvey* 1687 (US); TRAVIS COUNTY: Colorado River Flood Plain; Mar. 19, 1909, *Heald & Wolf* (T); Apr. 18, 1917, *Young* (T); Mar. 29, 1921, *Tharp* (T); East 19th Street, Austin, Apr. 21, 1909, *Heald* (T); May 5, 1935, *Whitehouse* 568 (C, M, US); Hornsby's Bend, Apr. 29, 1935, *Whitehouse* 572 (T); Pierdernaes Crossing, May 5, 1936, *Whitehouse* 583 (U.S.).

This *Phlox* has long been considered a variety of *P. Drummondii* Hooker to which it is closely related and from which it is with difficulty separated on leaf shape. In the field it is an exceedingly easy matter to distinguish them because of the marking and coloring of the corolla. In herbarium specimens the coloring of the corolla can only be used to supplement other characters.

Some specimens are small plants about 9 cm. high, with leaves much shorter and narrower than usual. These should be considered of depauperate growth rather than as a variety. Plants grown in deep loose sand on river flood plains show numerous basal branches with an increased number of alternate leaves, spatulate to obovate in shape. Some specimens are unbranched plants 35 cm. high with internodes as much as 35 mm. long, between the numerous alternate leaves. The alternate leaves on some specimens are 6 cm. long and 10 mm. wide.

Several specimens collected in Eastland County show differences which seem to indicate hybridization with *P. Roemeriana* which may be found in the same region. Hybridization with *P. Drummondii* may be responsible for some of the variations noted among the plants in the western part of Bastrop County. The plants collected in Robertson County may possibly belong in the list of hybrids with *P. Drummondii* or they may be cultivated escapes.

### 3. *Phlox Goldsmithii* Whitehouse, sp. nov.<sup>7</sup>

*Phlox Drummondii* auths., not Hooker. (1935).

*Phlox villosissima* auths., not (A. Gray) Small (1903).

Radix annua, caulis 10-25 cm. altus, ramosus, pubescens vel subglaber, foliis inferioribus oppositis, oblanceolatis, 2.5-5 cm. longis, superioribus alternis, 2.5-5 cm. longis et 5-12 mm. latis, glabris, apice acuminatis; cymis densifloris (4-10), 3-4- pedicellatis, calyce 9-12 mm. longo, villosa, laciniis lineari-acuminatis, aristatis, corolla purpurea, oculo atrifusco, tuba pubescenti, glanduloso, 15-17 mm. longo, laciniis limbi obovatis, ovario 3- loculari, loculis 1- ovulatis, capsula 3-4 mm. diam., globosa.

Root annual, short; stem 10-25 cm. high, stout, pubescent, with long soft hairs or nearly glabrate; branches at base opposite, divaricate-ascending to height of central stem; upper branches alternate; leaves thin, oblanceolate, hairs soft, eglandular, few or none on leaf surfaces, few on lower midnerve and on margins; lower leaves 3.5-6.5 cm. long and 3-9 mm. wide, usually 7-8 mm. wide; upper leaves alternate, apex acuminate, 2.5-5 cm. long and 5-12 mm. wide, rounded at base; bracts oblong-lanceolate 15-20 mm. x 2.5 mm.; bracte-

<sup>7</sup> The specific name honors the late Dr. G. W. Goldsmith, Professor of Botany of the University of Texas.

oles linear-lanceolate, narrowed at base 10-15 mm. long, not subtending base of second pedicel but leaving its axis 2-3 mm. from the base of the terminal pedicel; inflorescence densely cymose, flat-topped cluster, peduncles 2-4, terminal and second 4-flowered, 4-35 mm. long, third and fourth peduncles usually compound, 3-6 cm. long, pedicels stout, 5-12 mm., some flowers of each peduncle usually in bloom at one time; calyx pubescent with long soft eglandular hairs with numerous short glandular hairs near base, 9-12 mm. long, lobes slightly longer than the tube, slightly thickened, linear-acuminate, awn about .5 mm. long, membrane plicate, midnerve not visible until capsule mature; corolla tube 15-17 mm., pubescent with short glandular and slightly longer eglandular hairs; throat short, dark within, pubescent below; limb purple, marked at base with red star eye which on aging of flower shows white halo; lobes ovate, apex erose or apiculate, 6-9 mm. wide and 8-9 mm. long; stamens inserted at different levels in middle half of tube; anthers 2.25 mm. long; pistil 4 mm. long; ovary 1.25 mm., cells 1-ovuled; style .75 mm.; stigmas linear 1.75 mm. long; disc green, margins erose or 10-lobed; capsules globose, 3.5 mm. high, 3-seeded; seeds 2.5 mm., dark gray, coat glaucous, rugose, raphae deep and narrow.

*Distribution.*—In open post oak woods between Guadalupe and Aransas Counties, south to Live Oak County, Texas.

*Specimens examined.*—TEXAS: ARANAS COUNTY: Rockport, Feb. 28, 1938, *Whitehouse* (595); BEE COUNTY: Beeville, Mar. 19, 1930, *Benke* 413 (F); Mar. 18, 1934, *Whitehouse* 503 (ANS, B, C, F, US T); GOLIAD COUNTY: Victoria-Goliad, Mar. 28, 1930, *Tharp et al.* (T); Mar. 1927, *Williams* 19 (T); GAUDALUPE COUNTY: Sequin-Lavernia, Mar. 30, 1933, *Whitehouse* 501 (D, M, NY, T, US); JACKSON COUNTY: Arenosa River, July 2, 1915, *Drushel* (M); KARNES COUNTY: neutral sandy soil of open post oak and mesquite woods, Nixon-Gillett, Mar. 15, 1934, *Whitehouse* 508 (ANS, BIM, C, G, M, ND, NY, RM, US Typ5); Feb. 28, 1938, *Whitehouse* 593 (ANS, G, M, NY, US); Kennedy-Yorktown, Mar. 18, 1934, *Whitehouse* 506 (ANS, RM, T) and 507 (C, USDA); LIVEOAK COUNTY: *Tharp* (T); George West-Alice, Apr. 22, 1934, *Whitehouse* 511 (US) & 529 (ANS, F, NT); George West-Clegg, Mar. 15, 1934, *Whitehouse* 527 (B, C, F, NT, T, US); Alice to San Diego, *Whitehouse* (T); REFUGIO COUNTY: north of Tivoli, Feb. 28, 1938, *Whitehouse* 596 (T); SAN PATRICIO COUNTY: Sinton-Refugio, Apr. 1, 1934, *Whitehouse* 505 (C, F, NT, RM, US); VICTORIA COUNTY: Victoria, Apr. 6, 1900, *Eggert* (US); Apr. 4, 1905, *Lewton* (US); Apr. 28, 1905, *Maxon* (US); Mar. 4, 1916, (M); Mar. 1903, *Shear* (US); May 25, 1930, *Tharp* (T); Apr. 26, 1906, *Tracy* 9436, (G, F, US); Victoria-Goliad, Mar. 29, 1930, *Tharp & Class* (T); Apr. 21, 1934, *Whitehouse* 216 (T, US); WILSON COUNTY: Stockdale, Mar. 15, 1934, *Whitehouse* 509 (ANS); Feb. 27, 1938, *Whitehouse* 594 (C, F, T, US).

The flowers of this species show a marked variation in color with age. The flowers upon opening are more of a lavender color with short maroon marks at the base of the lobe with a white halo on each side of this. The central-marking of the lobe is a deep purple. The older flowers take on more of the red color throughout, the limb becoming phlox purple in color with a red star forming the eye at the base of the lobes and white no longer visible. The color of the throat is usually purple but is sometimes white.

Various large collections show variations with respect to the length and width of the leaves, the amount of pubescence, and the development of the calyx.

The inflorescence shows a number of interesting variations, one of which

is the frequent tendency to the formation of only two flowers in a cluster instead of the usual four.

Both external and internal evidence indicated that some of the plants collected at Beeville were of hybrid origin with *P. cuspidata* which was also collected just a short distance away.

This species seems to prefer the more neutral sands where the black land prairies meet the post oak sands.

4. *PHLOX CUSPIDATA* Scheele, *Linnaea* 23:139. 1850, not Gray, *Syn. Fl.*, 1888, Brand in Engler's *Pflanz.* IV. 250:69. 1907, not Wherry, *Bartonia* 12:38. 1931.

*Phlox Drummondii* Hook. var. *tenuis* Gray, *Proc. Amer. Acad. Arts & Sci.* 8:257. 1870; Gray, *Syn. Fl.* 2, 1:134. 1886; Coulter, *Contr. U. S. Nat. Herb.* 2:276. 1892; Brand in Engler's *Pflanz.* IV. 250: 70. 1907.<sup>8</sup>

*Phlox tenuis* (Gray) Nelson, *Ann. Report Wyo. Agr. Exp. Sta.* 9:35. 1899; Small, *Fl. S. E. U. S.* ed. 1, p. 977. 1903, & ed. 2, p. 977. 1913; Whitehouse, *Tex. Fl. Nat. Col.* p. 109. 1936 (col. pl.).

- 4a. *Phlox cuspidata* var. *typica* Whitehouse, var. nov.

*Phlox cuspidata* Scheele, *Linnaea* 23:139. 1850.

Annual, paniculata, foliis spatulatis, 15-35 mm. longis, floribus cymosis, corollae tubo 8-12 mm. longo, lobis 6-7 mm. longis, 3-4 mm. latis.

Root annual, very small; stem commonly erect, 10-20 cm. high, internodes 5-18 mm., occasionally branched at the base, several upper alternate branches, pubescent with short glandular hairs, hairs sometimes retrorse; lower leaves bright green, oblanceolate-spatulate, opposite, about 4 pairs, 15-35 mm. long and 4-6 mm. wide, nearly glabrous; mid-stem leaves narrowly linear or linear-lanceolate, apex usually acute; bracts narrowly linear-lanceolate, 1.5-2.5 cm. long and 2-3 mm. wide; inflorescence peduncles 1-4, 4-flowered, pedicels 2-4 mm. long; calyx 7-8 mm. long, tube shorter than the lobes, pubescent with short glandular hairs, midrib very conspicuous in tube, lobes linear-aristate, flattened; corolla tube 8-12 mm. long, pubescent, constricted 2 mm. above base, not hairy within, lobes usually two times as long as wide, cuneate, with apex usually mucronate, margin often erose, upper surface conspicuously papillose, lobes pale phlox-purple with two short lateral maroon marks at base of lobe, throat pale, often with outer rim of blue; pistil 3 mm. long, ovary ovoid, 1.25 mm., style .5 mm.; stigma 1.25 mm.; capsules globose, 3 mm. high, 3 carpels 1-ovuled; seeds 3, grayish-brown, elliptical, 2-2.25 mm., raphe deep and narrow, rugae narrow and prominent.

*Distribution*.—Coastal plain from San Patricio to Orange Counties, north along borders of post oak woods of Central Texas to Durant, Oklahoma.

*Type*.—Collected on the prairie near Pine Island, Texas, April, 1847 (?), F. Roemer.

<sup>8</sup> Priority of publication invalidates the name of *Phlox tenuis* Wooten & Standley (1916) as applied to a perennial plant of New Mexico and *Phlox cuspidata* (Wittmack) Brand (1905) applied to *Phlox Drummondii* var. *cuspidata* Wittmack (1888).

**4b. *Phlox cuspidata* var. *grandiflora* Whitehouse, var. nov.**

Caulis 10-13 cm. altus, foliis 20-35 mm. longis, 4-6 mm. latis, inflorescentia compacta, 4-8-flora, brevi-pedicellata, calyce 7-10 mm. longo, corollae tubo 11-13 mm. longo, lobis 9-11 mm. longis, 6-8 mm. latis, ceterum speciei similis.

Stem usually strict, 10-13 cm. high, but occasionally with 2 basal branches; cotyledons oblong-spatulate, 10-14 mm.; lower leaves opposite, narrowly oblanceolate, 20-35 mm. long, 4-6 mm. wide; inflorescence compact, peduncles scarcely exceeding the terminal cluster, the upper two not leafy; 4-8-flowered; pedicels very short; calyx 7-10 mm. long, lobes linear-acuminate; corolla tube 11-13 mm. long, lobes 9-11 mm. long and 6-8 mm. wide.

*Distribution*.—Open woods in Bastrop, Caldwell, Gonzales, and DeWitt Counties, Texas.

*Specimens examined*.—TEXAS: BASTROP COUNTY: Bastrop, 1928, Duval (US); Apr. 17, 1928, Palmer 33374 (G, M, NY, US, T); Mar. 20, 1921, Tharp 683 (US); Apr. 16, 1922, Tharp 1365 (US, T); Apr. 8, 1923, Tharp 1958 (US TYPE, T); Apr. 6, 1929, Tharp 5660 (US, T); Mar. 24, 1931 (T); Apr. 1930, Tharp (T); Mar. 31, 1934, Whitehouse 567 (ANS, BIM, C, F, G, M, ND, NT, NY, RM, T, US, USDA); McDade, Apr. 19, 1930, Fisher (US); CALDWELL COUNTY: Spring, 1931, McBryde (T, US); GONZALES COUNTY: Apr. 1924, Schulz (F); Cuero-Gonzales, Mar. 13, 1931, Tharp (T); Apr. 18, 1931, Tharp (T); DEWITT COUNTY: Cuero, Mar. 28, 1931, Whitehouse (T).

Because the leaves are prevailingly opposite with few alternate leaves on the upper branches, this plant was usually identified with *Phlox aspera* before the latter was shown by Wherry to be a perennial. The plant did not tally very closely with the description of *P. aspera*, nor with that of *P. villosissima* to which it was sometimes referred.

Little variation was noted except a few of the plants from Bastrop were larger, with long internodes, and foliage slightly hispidulous pubescent.

**4c. *Phlox cuspidata* var. *humilis* Whitehouse, var. nov.**

Caulis simplex vel ramosus, 6-13 cm. altus, gracilis, foliis inferioribus oppositis, 13-20 mm. longis, 2-4 mm. latis, foliis alternis, 20 mm. longis, apice acutis, pedicellis gracillimis, 3-4 mm. longis, calyce 8-9 mm. longo, corollae tubo calyce vix longiore, 8-10 mm. longo, lobis 6 mm. longis, 3 mm. latis, ceterum speciei similis.

Stem simple or branched, 6-13 cm. high; lower leaves 13-20 mm. long and 2-4 mm. wide; alternate stem leaves few, linear; apex acute, 20 mm. long; calyx 8-9 mm. long; corolla tube 8-10 mm. long, lobes 6 x 3 mm.; seeds markedly small.

*Distribution*.—Black waxy prairies on the coast and in North Central Texas.

*Specimens examined*.—TEXAS: CALHOUN COUNTY: Magnolia Beach prairie, Mar. 22, 1930, Tharp (T, US); also Mar. 13, 1931, Tharp (T); Apr. 18, 1931, Tharp (T); May 22, 1930, Tharp (T); Magnolia Beach, Apr. 1, 1934, Whitehouse 561 (T); DEWITT COUNTY: Cuero, Mar. 22, 1907, Howell 424 & 333 (US); FANNIN COUNTY: Bonham, Apr. 1896, Milligan (US); GRAYSON COUNTY: Denison, May 9, 1932, Polson (T); REFUGIO COUNTY: Austwell, Mar. 11, 1931, Tharp (T, US); Woodsboro, Mar. 17, 1929, Tharp (T); TARRANT COUNTY: Handley Prairie, Apr. 21, 1926, Killian 6915 (US); Grapevine, May 1878, Reverchon (M TYPE); Apr. 18,

1919, *Ruth 793* (US); VICTORIA COUNTY: Victoria, Mar. 5, 1916, *Palmer 9098* (US); Apr. 4, 1905, *Lewton 9* (US); Mar. 28, 1936, *Whitehouse* (ANS, T).

5. *Phlox Tharp* Whitehouse, sp. nov. <sup>9</sup>, <sup>10</sup>

*Phlox villosissima* auths., not (A. Gray) Small (1903).

*Phlox Drummondii* var. *villosissima* auths., not A. Gray (1886).

*Phlox aspera* auths., not Nelson (1899).

*Radix annua*, caulis erectus vel ramosus, 10-30 cm. altus, foliis inferioribus lineari-spathulatis, 3-5 cm. longis, 2.5-5 mm. latis, apice acutis vel acuminate, foliis superioribus alternis, lineari-acuminatis, 3-7 mm. latis, 3-5.5 cm. longis, marginibus ciliatis, ceterum glabris, inflorescentia 2-3-pedicellata, 12- flora, calyce 7-10 mm. longo, glanduloso, corollae tubo 16-17 mm. longo, pubescenti, lobis 13x7.9 mm. diam., purpureis, capsula ovoidea, 4 mm. longa, 3-sperma, seminibus ovoideis.

Root annual, very slender; stem pubescent with long soft eglandular hairs, simple or with a few basal branches, 10-30 cm. high; leaves thin, lower oblinear, apex acute to acuminate, 3-5 cm. long, and 2.5-5 mm. wide, 5 pair opposite, the upper with sessile not petiolate bases, the fourth pair longer; alternate leaves linear, base sessile and slightly narrowed, apex acuminate, 3-7 mm. wide and 2-5.5 cm. long, nearly glabrous on upper surface and few scattered hairs on lower surface, margins ciliate, sometimes undulate; bracts lance-acuminate, base sessile, 15-25 mm. long and 2-4 mm. wide; bracteoles linear, 12 mm. long and 1.5 mm. wide; inflorescence 2-3 peduncles, glandular pubescent, 5-40 mm. long, each 4-flowered, little difference in height of fruits at maturity, pedicels 5-9 mm. long, stout; calyx 7-10 mm. long, lobes recurved, slightly thickened with callous tip about 1 mm. long, midnerve prominent about  $\frac{3}{4}$  length, glandular pubescent; corolla tube 16-17 mm. long, densely short-glandular pubescent, narrowed 2.5 mm. above the base, not hairy within; lobes cuneate, almost rhomboidal, margins of apex often erose, 13 x 7.9 mm., purple, midnerve marking at base reddish-purple, inner throat dark purple and outer pubescent; stamens inserted in upper half of tube, anthers 2.5 mm. long; pistil 3.5-4 mm. long; ovary ovoid, 3-ovuled, 1.5 mm. long; style 1.5 mm. long; disc wavy-margined; capsules 4 mm. long, ovoid; seeds 3, brownish-gray, 2.5-1.5 mm., rugae very irregular and sharp, rhaepae narrow and deep, slightly winged.

*Distribution*.—In sandy soil in Bexar, Atascosa, Medina, Frio, and Dimmitt Counties, Texas.

*Specimens examined*. TEXAS: ATASCOSA COUNTY: Leming, May 2, 1918, *Schulz 78* (US); Campellton-Pleasanton, Apr. 22, 1934, *Whitehouse 502* (C. M. USDA); Pleasanton, May 16, 1928, *Palmer 33737* (G, US); Apr. 17, 1920, *Schulz 86* (US); BEXAR COUNTY: *Berlandier 1470* (ANS); De Bejar a Austin, Apr. 1828, *Berlandier 323* (G); 16 miles south of San Antonio, Apr. 28, 1931, *Schulz* (US, T); San Antonio, Mar. 12, 1931, *Tharp* (T); DIMMITT COUNTY: 9 miles southwest of Carrizo Springs, Apr. 14, 1934, *Whitehouse 568* (ANS, B, BIM, C, F, G, M, ND, NT, NY, RM, T, US, USDA), 569 (ANS, F, US), 570 (ANS, G, M, ND, NY, T), and 571 (B, T, US); Carrizo Springs, May 4, 1928, *Palmer 33737* (G, US); FRIO COUNTY: Derby, Apr. 15, 1934, *Whitehouse 570* Dilley, Feb. 27, 1930, *Tharp* (T); Moore, May 9, 1928, *Palmer 33860* (G, M, US); MEDINA COUNTY: 30 miles west of

<sup>9</sup> Incompletely described in *Whitehouse, Tex. Fl. Nat. Col.* p. 109. 1936. (Col. 1, inaccurate because of printer's exchange of plates.)

<sup>10</sup> The specific name honors Dr. B. C. Tharp, Professor of Botany at the University of Texas, a noted collector of Texas plants.



San Antonio, Sept. 1879, Palmer 844; Devine, Apr. 13, 1934, *Whitehouse* 217 (ANS, BIM, C, F, G, M, ND, RM, T, US TYPE); Lytle-Devine, Apr. 4, 1930, *Hoglund* (T); NUECES COUNTY: Nuecestown, Apr. 2, 1896, *Marlatt* (US); UVALDE COUNTY: Sabinal (?) between San Antonio and Del Rio, Apr. 21, 1925, *Small & Wherry* (NY); Pena, Tex., 1889, *Neally* 307 (F, US).

The appearance of this annual *Phlox* is very much like that of *P. villosissima*, a perennial whose type locality is on the Nueces River not many miles from the region where *P. Tharp* is to be found.

The shorter corolla tubes is usually noted on flowers blooming late in the season. Plants from Carrizo Springs and at Derby show variations which might set them aside as varieties, however differences in growth conditions make this seem inadvisable.

6. *Phlox littoralis* (Cory) *Whitehouse*, comb. nov.

*Phlox Drummondii* var. *littoralis* Cory, *Rhodora* 39:421. 1937.

*Phlox Helleri* *Whitehouse*, *Tex. Fl. in Nat. Col.* p. 109. 1936.

Root annual, very slender; central stem 6-10 cm. high, pubescent above with long soft glandular hairs, very slender, few internodes; upper branches alternate, few and short; basal branches numerous, very slender and widely spreading, often purplish, 15-27 cm. long; lower leaves opposite, linear-lanceolate with narrowed, indented bases, 5 cm. long and 3-5 mm. wide; upper leaves alternate, slightly broader, sessile, bases rounded, 16-23 mm. long, 5-7 mm. wide; branch leaves 10-23 mm. long, linear-lanceolate, often ensiform; inflorescence loosely cymose, peduncles 2-4-flowered, peduncles 2 cm. or less in length, pedicels 2-8 mm., very slender; branches commonly with only two peduncles; calyx often purplish, 7-9 mm. long, the lanceolate lobes nearly twice as long as the tube, densely pubescent with numerous long slender eglandular hairs and short viscid glandular hairs, mid-nerve conspicuous on lower half, lobes abruptly aristate; corolla tube yellowish, pubescent, 9-14 mm. long, constriction about 2 mm. above the base; throat stiff; white above, short, funnel-shaped; limb purple, 15-22 mm. broad, lobes cuneate, 6-8 mm. wide and 6-9 mm. long, apex rounded, apiculate; pistil 2.7 mm. high, stigmas and ovary same length, style one-half as long, thick; capsule 4 mm. high, globose; seeds 3, light brown, oval, 1.5-2.5 mm. long, slightly glaucous, mostly with a large lumen, raphe narrow and fairly deep, rugae shallow and irregular.

*Distribution*.—Coastal counties between Matagorda and Nueces Bays, Texas.

*Specimens examined*.—TEXAS: ARANAS COUNTY: near Laguna de San Nicolas, May, 1829, *Berlandier* 1950 and 560 (G); near Copano Bay, Mar. 28, 1936, *Whitehouse* 603 (BIM, C, F, ND, NT, RM, T, USDA); Rockport, Apr. 1, 1934, *Whitehouse* 591 (T) & 590 (B, C, F, G, M, US); CALHOUN COUNTY: Port O'Connor to Seadrift, Mar. 29, 1930, *Tharp* (T); NUECES COUNTY: Flour Bluff, May 20, 1936, *Cory* 20574 (G); Nueces Bay, Mar. 12, 1894, *Heller* 1435 (ANS, M, T, US); REFUGIO COUNTY: Austwell, Mar. 14, 1931, *Tharp* (T); near Austwell, Apr. 1, 1934, *Whitehouse* (T); Refugio-Sinton, Apr. 1, 1934, *Whitehouse* 602 (T); SAN PATRICIO COUNTY: 1.8 miles SW. Aransas Pass, May 19, 1936, *Cory* 20393 (G TYPE); Mustang Island, Apr. 15, 1933, *Whitehouse* 400 (T).

This species is evidently of more recent origin than the other annuals. It is found only on the beach sands, being very abundant in some regions. It starts blooming early in the year, and some plants continue until late summer. The plants along the coast show little variation, but on the inner boundary of their

range there is some variation as well as some possible evidences of hybridization.

Cory's description, with Latin diagnosis, properly ignores the publication of *P. Helleri* by the writer in 1936 (the Latin description for which had been omitted with the expectation that the present paper would precede its publication). The name *P. Helleri* is thereby invalidated.

As Cory's specimens were collected late in the season, most of them are minus basal leaves, capsule, and central stem leaves. For this reason an emended description is given above.

7. *PHLOX GLABRIFLORA* (Brand) Whitehouse, *Bull. Torr. Bot. Club* 62:384. 1935; *Tex. Fl. Nat. Col.* 108. 1936.

*Phlox Drummondii* Hook. ssp. *glabriflora* Brand, *Engler's Pflanz.* IV. 250:71. 1907.

*Distribution*.—Nueces County to Willacy and Webb Counties, Texas, abundant; from the Nueces River to the Medina River, Texas, and from Orange County, Texas, rare.

*Type*.—In sandy places between the mouth of the Nueces River and Arroyo del Colorado (Cameron County), April, 1834, *Berlandier* 2526 in Herb. DC. (Co-type in Gray Herbarium.)

8. *PHLOX ROEMERIANA* Scheele, *Linnaea* 21:752. 1848.

*Phlox macrantha* Buckley, *Proc. Acad. Phil.* 63:5. 1862.

*Phlox roemeriana elata* Brand, *Geneva Ann. Conserv. Bot.* 15-16:327. 1911-1913.

*Distribution*.—Limestone hill region of Central Texas.

*Type*.—New Braunfels, Texas, 1846, *Roemer*, deposited in the Herbarium of the Missouri Botanical Garden.

### Conclusions

In order to account for essential differences in flower color, pubescence, shapes of different organs, leaf structure, and stem anatomy, it has been necessary to make several revisions in the nomenclature of the annual species. *Phlox Drummondii* Hooker should be limited to the red-flowered plants indigenous to central Texas and the vari-colored plants arising in cultivation which have the same general morphological characteristics, since Drummond's original collection of seeds evidently included some from native hybrids.

In all, eight species of annuals are recognized. Each of two species seem best treated as composed of three varieties. Of the species *P. cuspidata* was described in 1850 by Scheele, but this description has not previously been assigned to the dwarf annual which has usually been known as *P. tenuis* (Gray) Nelson. *P. Roemeriana* var. *elata* Brand is considered an ecological variant rather than an established variety of the widespread *P. Roemeriana*. New combinations introduced by the present writer include raising to specific rank *P. Drummondii* ssp. *glabriflora* Brand and *P. Drummondii* var. *littoralis* Cory, and reducing *P. Wilcoxiana* Bogusch and *P. Heynholdii* Grieve to varietal rank in *P. Drummondii*. Three new species, *P. McAllisteri*, *P. Goldsmithii*, and *P. Tharpii*, and five new varieties, *P. Drummondii* vars. *typica* and *instabilis*, *P. cuspidata* vars. *typica*, *grandiflora*, and *humilis*, have been described.

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# Some Chemical Factors Influencing the Distribution of Aquatic Plants in Minnesota

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## Introduction

Minnesota has an abundance and great variety of aquatic plants growing in 10,000 lakes and more than 16,000 miles of streams. The lakes, which cover more than 5 per cent of the state's surface, lie at the headwaters of the Mississippi River, St. Lawrence River, and Hudson Bay drainage basins. They vary in form from the rocky shored oligotrophic lakes of the northeast, through the typically eutrophic lakes of the central and northern morainic areas to the shallow prairie lakes of the southwestern and extreme western counties, and range in size from a few acres to several hundred square miles. The surface and underlying geology of Minnesota are not only reflected in the number, form, and size of the lakes but also in the chemical quality of their waters. Nearly the entire carbonate range of fresh surface waters is represented as well as the lower end of the sulphate or alkali water series that is most characteristically developed in more western and arid regions.

Since Minnesota waters exhibit a wide range of general chemical characteristics, it was decided in 1934 to examine the relationship existing between the chemical nature of the waters and the general distribution of aquatic plants. This investigation was carried out at the University of Minnesota under the guidance of Dr. C. O. Rosendahl<sup>2</sup> of the Department of Botany and submitted as a thesis for the degree of Doctor of Philosophy in 1939.

## Data Collected and Techniques

Field surveys were made of 225 lakes and streams scattered over the entire state. Waters were selected that were representative of the chemical range of Minnesota surface waters. The plants inhabiting the different bodies of water were recorded. Unusual species or plants of uncertain identity were collected and deposited in the University of Minnesota Herbarium. All of the distributional records considered are based upon plants examined by the writer. To determine the general chemical characteristics of the waters, analyses were run

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for total alkalinity (temporary hardness), sulphate ion concentration, and hydrogen ion concentration (pH). Total alkalinity was determined in the field by titration with 0.05N  $H_2SO_4$  using bromcresol green as an indicator and includes all carbonates (and hydroxides if present) expressed as parts per million of calcium carbonate. Hydrogen ion concentration was determined in the field with La Motte and Hellige comparators. Because of the variability of pH in lake waters, especially in the vicinity of weed beds (Oosting 1933), pH readings were taken only from open water. Since sulphate salts are also present in considerable concentrations in many Minnesota waters, laboratory determinations for sulphate ion were made. When present in low concentrations the sulphates were determined turbidimetrically, using concentrated HCl and saturated  $BaCl_2$  as reagents. When sulphates were present in concentrations greater than 15.0 parts per million, the titration technique of Sheen and Kahler (1936) was used. Sulphates are expressed as parts per million of the sulphate ion.

#### Review of the Literature

Although fresh-water, brackish-water, and marine floras have long been recognized, only a few workers have investigated the water quality preferences of the component members of these floras. Much of the published work is general and observational in nature. Among the more important papers giving general water quality preferences of some aquatic plants are West (1905), Tansley (1911), St. John (1920), Samuelsson (1925), Drew (1936), and Coston, Pentelow and Butcher (1936). Iversen (1929) found in the lakes of Denmark that the distribution of aquatic plants could be related to the pH of the waters. Harshberger (1911), Bourne (1932, 1934, 1935) and Penfound and Hathaway (1938) demonstrated that salinity is an important factor. In central North America the most important papers are those of Metcalf (1931) who related the distribution of aquatic plants in North Dakota lakes to the total dissolved mineral content of the water, and Fassett (1930) and Wilson (1935) who list the aquatic plants of some Wisconsin lakes with carbonate and pH readings of the waters. Much of the European work in this field has been summarized by Naumann (1932) and Samuelsson (1934), and most of the more important American papers are considered by McAtee (1939) and Martin and Uhler (1939).

The influence of the nature of the bottom soil upon the growth of aquatic plants was not appreciated until Pond (1905), Snell (1908), and Brown (1911) demonstrated that many rooted aquatic plants derive much of their nutriment from bottom soils and that the roots of the plants are organs of absorption as well as organs of anchorage. More recently, Pearsall (1920, 1929) and Misra (1938) emphasized the effect of the nature of the bottom soil upon the local distribution of water plants.

#### Chemical Quality of Minnesota Surface Waters

In northeastern Minnesota where Pre-cambrian rocks are exposed or but lightly mantled with non-calcareous glacial drift, the lakes frequently have a total alkalinity of less than 50 parts per million, a concentration of sulphate ion less than 5 parts per million, and a summer pH of surface waters ranging

between 6.8 and 7.4. Many such waters have a total alkalinity between 10 and 20 parts per million. The lakes of the deep limy glacial soils of central and northern Minnesota are considerably harder and commonly range in total alkalinity from 75 to 200 parts per million, in sulphate ion concentration from 0 to 10 parts per million, and in summer pH of surface waters from 8.0 to 8.8. In the southwestern and extreme western counties the limy glacial drift is underlain by Cretaceous formations that are rich in soluble minerals. Drainage from these formations and the glacial soils derived from them has high concentrations of both carbonate and sulphate salts. The lakes of this area commonly range in total alkalinity from 100 to 250 parts per million, in sulphate ion from 50 to 300 parts per million, and in summer pH from 8.4 to 9.0. Lakes of this chemical type are generally known as "alkali" lakes, and those with higher salt concentrations are often characterized in summer by a white crust of salts on drying mud flats. The 225 lakes and streams surveyed ranged in total alkalinity from 0.5 to 376.0 parts per million, in sulphate ion content from 0.0 to 1,296.6 parts per million, and in pH from 6.3 to 9.2.

Climate has also been an important factor in the development of the widely divergent chemical quality of Minnesota lake waters. In the cooler northern and northeastern parts of the state, summer evaporation has been a less important factor in concentrating dissolved minerals in lake waters than it has been in southern and southwestern Minnesota. Although the climate and geology of the state have caused the existence of these three chemical types of lake waters, it should be pointed out that no sharp separation exists between them and that the waters of the state form a general but irregular series, increasing in concentration of dissolved minerals from northeast to southwest.

Analyses for the metallic ions were not made but other available analyses show that the calcium is the predominant ion, following in descending order by magnesium, sodium and potassium, aluminum, and iron (Dole and Westbrook, 1907; Hall, Meinzer and Fuller, 1911; Allison, 1932). In most cases this general order holds regardless of the total salt concentration. Chloride ion is seldom present in amounts exceeding 5 parts per million and, as has been shown by a large series of analyses run for the Minnesota Department of Conservation by the writer and others, the total phosphorus concentration in Minnesota waters commonly ranges from 0.02 to 0.1 parts per million and the total nitrogen concentration between 0.2 and 2.0 parts per million.

The terms "hard" and "soft" as applied to carbonate waters in this paper are based upon observed preferences and tolerances of aquatic plants. On this basis the natural separation between hard and soft waters seems to be at a total alkalinity of about 40 parts per million, 30 parts per million being the lower limit of toleration of the more typical hard-water species, and 50 parts per million the upper limit of toleration of the more characteristic soft-water species. On a similar compromise basis the dividing line between hard carbonate and alkali waters seems to be a sulphate ion concentration of about 125 parts per million. A sulphate ion concentration of 50 parts per million is the lower limit of toleration of such typically alkali water species as *Ruppia occidentalis* S. Wats. and a concentration of 300 parts per million is the upper limit tolerated by most hard-water species.

### The Minnesota Aquatic Flora

Since the aquatic flora merges gradually into the marsh and swamp flora and this, in turn, fades into the flora of the uplands, any delineation of an aquatic flora must be somewhat arbitrary. In Minnesota there are 175 different plants that are usually considered to be aquatic. These include 143 species and varieties of seed plants, 4 species of fern allies, 20 species of mosses and liverworts, and several species of Charophytes. Ninety-seven of the seed plants are monocotyledons and 46 dicotyledons. Of the 33 families of seed plants present in the aquatic flora, the larger and most typically aquatic are *Najadaceae* with 32 species, *Alismaceae* with 6 species, *Hydrocharitaceae* with 3 species, *Lemnaceae* with 6 species, *Nymphaeaceae* with 8 species, and *Haloragidaceae* with 6 species. Considering the state as a whole, the most abundant aquatic plants are *Typha latifolia* L., *Potamogeton pectinatus* L. *Potamogeton Richardsonii* (Benn.) Rydb., *Najas flexilis* (Willd.) R. & S., *Sagittaria latifolia* Willd., *Scirpus acutus* Muhl., and *Ceratophyllum demersum* L.

### Water Quality and Distribution of Aquatic Plants

On the basis of the chemical quality of Minnesota's surface waters, the aquatic plants inhabiting them fall into three general groups: (I) the flora of the soft-water lakes that are most frequent in northeastern Minnesota, (II) the flora of the hard-water morainic lakes of the central, northern, and southern part of the state, and (III) the flora of the alkali or high sulphate lakes of the extreme western and southwestern prairies. Although three more or less distinct aquatic floras can be delimited, actually each species of aquatic plant has its own range of chemical tolerance and set of chemical conditions under which it makes its best growth. Some species are limited in distribution to a single chemical type of water, others occur in two of the three types, and a few such tolerant species as the common cattail occur in all three. The ranges of carbonate, sulphate, and pH tolerance for the more common Minnesota aquatic plants and the medians of these ranges are presented in Table 1. The median has been chosen as the best index of conditions most frequently associated with any species since the mean is frequently weighted by a few excessively high analyses from waters where the plant was of rare or unusual occurrence. Several species that are characteristic of alkali waters, such *Potamogeton pectinatus*, *Ruppia occidentalis*, and *Scirpus paludosus*, have only the lower limits of their ranges of chemical tolerance in Minnesota waters, the upper limits in central North America being found in the more alkali waters of the Dakotas (Metcalf, 1927). For such species, valid medians for their entire range of chemical tolerance cannot be obtained from the Minnesota data.

In the following treatment the Minnesota aquatic flora is separated into three major groups on the basis of the median or most usual chemical conditions associated with each species. Subgroups are constructed on the basis of the entire range of chemical conditions tolerated by each species. Thus, *Potamogeton epihydrus* Raf. has a median status that places it in the soft-water flora (Group I) but has a range of chemical tolerance overlapping the hard-water flora and is so placed in Subgroup 2. The species included in the discussion of each group or subgroup are placed there on the basis of analyses



TABLE 1.—Tolerance of the more common Minnesota aquatic plants to total alkalinity, sulphate ion and hydrogen ion concentration of lake and stream waters.<sup>3</sup>

| Species   | Total Alkalinity<br>Median <sup>5</sup> Range | Sulphate ion<br>Median <sup>5</sup> Range | Hydrogen ion (pH)<br>Median <sup>5</sup> Range | No. Analyses <sup>4</sup> |         |             |
|---|---|---|--|---------------------------|---------|-------------|
| Equisetaceae  |   |   |  |                           |         |             |
| <i>Equisetum fluvatile</i> L. ....                                      | 45.0  | 5.8                                       | 0.0-16.0                                       | 7.7                       | 6.8-8.8 | 26, 7, 27   |
| Isoetaceae  |   |   |  |                           |         |             |
| <i>Isoetes Braunii</i> Dur. ....  | 31.8  | 0.6                                       | 0.0-4.5  | 7.6                       | 7.0-8.0 | 11, 4, 10   |
| Typhaceae   |   |   |  |                           |         |             |
| <i>Typha latifolia</i> L. ....  | 116.5   | 25.5                                      | 0.0-1296.2                                     | 8.3                       | 6.3-9.0 | 70, 42, 73  |
| Sagittariaceae  |   |   |  |                           |         |             |
| <i>Sagittarium chlorocarpum</i> Rydb. ....                              | 84.4  | ....                                      | 4.2-11.5                                       | ....                      | 7.3-8.4 | 4, 2, 2     |
| <i>S. eurycarpum</i> Engelm. ....                                       | 112.6   | 73.0                                      | 2.0-199.2                                      | 8.2                       | 7.2-8.8 | 24, 13, 28  |
| <i>S. fluculans</i> (Morong) Robinson ....                              | 31.1  | 1.0                                       | 0.5-6.0  | 7.2                       | 7.0-7.3 | 6, 5, 4     |
| Potamogetonaceae  |   |   |  |                           |         |             |
| <i>Potamogeton alpinus</i> Balbis. ....                                 | 31.8  | 2.3                                       | 0.5-4.1  | 7.5                       | 7.0-8.6 | 5, 2, 5     |
| <i>P. amplifolius</i> Tuckerm. ....                                     | 93.1  | 5.5                                       | 0.0-28.0                                       | 8.2                       | 7.1-8.8 | 34, 21, 39  |
| <i>P. angustifolius</i> Burchtold & Presl. ....                         | 108.8   | 11.5                                      | 0.5-143.3                                      | 8.1                       | 7.0-9.0 | 20, 12, 3   |
| <i>P. crispus</i> L. ....   | 140.0   | 36.5                                      | 21.5-41.0                                      | 8.2                       | 7.6-8.4 | 5, 3, 7     |
| <i>P. epiphydrus</i> Raf. ....  | 28.9  | 3.2                                       | 0.6-5.8  | 7.4                       | 6.7-8.6 | 18, 12, 20  |
| <i>P. foliosus</i> Raf., var. <i>genuinus</i> ....                      | 127.5   | 29.0                                      | 0.0-58.0                                       | 7.8                       | 7.2-8.4 | 5, 5, 6     |
| var. <i>macellus</i> Fern. ....   | 127.5   | 16.5                                      | 2.0-282.0                                      | 8.4                       | 7.4-8.8 | 15, 10, 17  |
| <i>P. Friesii</i> Rupr. ....  | 117.9   | 10.8                                      | 1.0-61.8                                       | 8.3                       | 7.7-8.8 | 11, 8, 12   |
| <i>P. gramineus</i> L., var. <i>graminifolius</i> Fries ....            | 37.5  | 4.5                                       | 0.0-17.0                                       | 7.7                       | 7.0-8.5 | 21, 9, 16   |
| var. <i>graminifolius</i> , f. <i>myriophyllus</i> (Robbins) House .... | 122.5   | 6.0                                       | 0.0-39.0                                       | 8.2                       | 7.0-8.8 | 35, 17, 44  |
| <i>P. illinoensis</i> Morong ....                                       | 127.5   | 32.5                                      | 0.0-18.0                                       | 8.3                       | 7.7-8.8 | 12, 7, 16   |
| <i>P. natans</i> L. ....  | 118.5   | 4.2                                       | 0.0-50.0                                       | 8.4                       | 6.8-9.0 | 28, 16, 25  |
| <i>P. nodosus</i> Poir. ....  | 117.0   | 16.0                                      | 5.0-199.2                                      | 7.9                       | 7.3-8.5 | 15, 11, 11  |
| <i>P. obtusifolius</i> Mert. & Koch ....                                | 31.8  | 0.5                                       | 0.5-2.0  | 7.2                       | 7.0-7.9 | 3, 3, 3     |
| <i>P. pectinatus</i> L. ....  | 140.0   | 21.1                                      | 0.5-1296.6                                     | 8.4                       | 6.3-9.0 | 85, 57, 101 |
| <i>P. pusillus</i> L. ....  | 110.4   | 5.5                                       | 0.0-17.0                                       | 8.0                       | 7.0-8.8 | 12, 9, 14   |
| <i>P. praelongus</i> Wulf. ....   | 114.4   | 8.0                                       | 0.0-143.3                                      | 8.2                       | 7.1-9.0 | 26, 15, 31  |
| <i>P. Richardsonii</i> (Benn.) Rydb. ....                               | 127.0   | 15.5                                      | 0.0-317.6                                      | 8.2                       | 7.0-9.1 | 70, 42, 83  |
| <i>P. Robbinsii</i> Oakes ....  | 72.5  | 2.8                                       | 0.0-18.0                                       | 8.0                       | 7.2-8.4 | 11, 4, 14   |



TABLE 1.—(Continued)

| Species   | Total Alkalinity<br>Median <sup>5</sup> | Range       | Sulphate ion<br>Median <sup>5</sup> | Range       | Hydrogen ion (pH)<br>Median <sup>5</sup> | Range   | No. Analyses <sup>4</sup> |
|---|---|-------------|-------------------------------------|-------------|--|---------|---------------------------|
| <i>P. Spirillus</i> Tuckerm.                                      | 32.5                                    | 18.7-46.0   | 0.5                                 | 0.0-3.0     | 7.4                                      | 7.0-8.3 | 11, 4, 10                 |
| <i>P. strictifolius</i> Benn., var. <i>rutiloides</i> Fern.       | 72.5                                    | 31.8-144.0  | 2.5                                 | 0.0-11.5    | 8.0                                      | 7.3-8.4 | 9, 4, 12                  |
| var. <i>typicus</i>   | 113.7                                   | 52.5-262.5  | 11.0                                | 4.0-18.0    | 8.2                                      | 7.4-9.0 | 10, 5, 14                 |
| <i>P. vaginatus</i> Turcz.  | 145.0                                   | 107.5-307.7 | 20.0                                | 15.0-50.0   | 8.4                                      | 8.0-9.0 | 6, 3, 7                   |
| <i>P. zosteraformis</i> Fern.                                     | 117.7                                   | 18.1-245.0  | 9.5                                 | 0.0-282.0   | 8.2                                      | 6.9-9.0 | 62, 39, 65                |
| <i>Ruppia occidentalis</i> S. Wats.                               | 252.8                                   | 146.8-376.0 | 93.5                                | 50.0-395.5  | 8.5                                      | 8.1-9.0 | 6, 5, 8                   |
| <i>Zamichellia palustris</i> L., var. <i>major</i> (Boenn.) Koch. | 190.0                                   | 75.0-337.5  | 41.0                                | 8.0-1296.6  | 8.4                                      | 7.6-9.0 | 17, 15, 21                |
| Najadaceae  |   |             |                                     |             |  |         |                           |
| <i>Najas flexilis</i> (Willd.) R. & S.                            | 122.5                                   | 18.7-307.7  | 11.3                                | 0.0-317.6   | 8.3                                      | 7.2-9.0 | 77, 40, 83                |
| <i>N. guadalupensis</i> (Spreng.) Morong                          | 140.0                                   | 75.0-159.8  | 107.7                               | 36.0-176.5  | 8.2                                      | 7.2-8.6 | 7, 5, 5                   |
| <i>N. marina</i> L.   | 228.7                                   | 146.8-376.0 | 93.5                                | 50.0-1296.6 | 8.5                                      | 8.2-9.0 | 5, 5, 9                   |
| Alismaceae  |   |             |                                     |             |  |         |                           |
| <i>Alisma Plantago-aquatica</i> L.                                | 115.0                                   | 31.8-297.5  | 36.0                                | 0.5-317.6   | 8.2                                      | 7.0-8.8 | 13, 7, 15                 |
| <i>Sagittaria cristata</i> Engelm.                                | 89.6                                    | 18.7-163.0  | 8.0                                 | 3.5-24.0    | 8.2                                      | 7.2-8.8 | 16, 5, 18                 |
| <i>S. cuneata</i> Sheldon   | 134.4                                   | 20.0-376.0  | 17.0                                | 2.0-317.2   | 8.5                                      | 7.3-9.0 | 13, 9, 17                 |
| <i>S. latifolia</i> Willd.  | 95.0                                    | 0.5-297.5   | 14.6                                | 0.0-199.2   | 8.0                                      | 6.3-8.8 | 65, 28, 64                |
| <i>S. rigida</i> Pursh  | 89.7                                    | 32.5-297.5  | 6.1                                 | 0.0-26.3    | 8.0                                      | 7.4-8.8 | 24, 11, 26                |
| Hydrocharitaceae  |   |             |                                     |             |  |         |                           |
| <i>Anacharis canadensis</i> (Michx.) Planchon.                    | 117.9                                   | 35.3-297.5  | 8.0                                 | 0.0-36.5    | 8.2                                      | 7.0-8.8 | 41, 15, 46                |
| <i>A. occidentalis</i> (Pursh) Victorin                           | 101.9                                   | 22.5-202.5  | 16.0                                | 0.0-282.0   | 8.1                                      | 7.3-8.8 | 21, 13, 33                |
| <i>Vallisneria americana</i> Michx.                               | 108.2                                   | 18.7-277.0  | 16.0                                | 0.0-317.6   | 8.2                                      | 7.0-8.9 | 51, 28, 55                |
| Gramineae   |   |             |                                     |             |  |         |                           |
| <i>Glyceria borealis</i> (Nash) Batchelder                        | 41.6                                    | 8.0-187.5   | 4.6                                 | 0.5-17.0    | 7.6                                      | 6.8-8.8 | 22, 8, 15                 |
| <i>G. grandis</i> Wats.   | 111.0                                   | 80.2-245.0  | 27.0                                | 2.0-61.8    | 8.1                                      | 7.2-8.8 | 12, 7, 10                 |
| <i>Leersia oryzoides</i> (L.) Swartz                              | 107.1                                   | 30.4-277.0  | 10.0                                | 0.0-178.0   | 8.4                                      | 7.2-9.0 | 27, 14, 30                |
| <i>Phalaris arundinacea</i> L.                                    | 63.7                                    | 22.5-134.4  | 17.0                                | 6.1-61.8    | 7.7                                      | 7.3-8.8 | 10, 5, 9                  |
| <i>Phragmites communis</i> Trin.                                  | 125.0                                   | 0.5-297.5   | 24.0                                | 0.5-395.5   | 8.2                                      | 6.3-9.0 | 40, 27, 44                |
| <i>Zizania aquatica</i> L.  | 167.5                                   | 37.5-297.5  | 21.2                                | 3.0-282.0   | 8.1                                      | 7.2-8.6 | 15, 10, 14                |
| <i>Z. aquatica</i> L., var. <i>angustifolia</i> Hitchc.           | 120.2                                   | 8.0-220.0   | 4.2                                 | 2.0-36.0    | 8.3                                      | 7.2-8.8 | 28, 10, 28                |
| Cyperaceae  |   |             |                                     |             |  |         |                           |
| <i>Eleocharis acicularis</i> R. & S.                              | 81.6                                    | 18.7-376.0  | 10.5                                | 0.0-317.6   | 8.3                                      | 7.0-8.0 | 29, 12, 33                |

TABLE 1.—(Continued)

| Species  | Total Alkalinity    |             | Sulphate ion        |             | Hydrogen ion (pH)   |         | No. Analyses <sup>4</sup> |
|--|---------------------|-------------|---------------------|-------------|---------------------|---------|---------------------------|
|  | Median <sup>5</sup> | Range       | Median <sup>5</sup> | Range       | Median <sup>5</sup> | Range   |                           |
| <i>E. palustris</i> (L.) R. & S. ....                    | 120.6               | 0.5-220.0   | 22.5                | 0.0-395.5   | 8.3                 | 6.3-9.0 | 42, 18, 47                |
| <i>E. palustris</i> , var. <i>major</i> Sonder           | 71.6                | 0.5-183.0   | 16.0                | 0.0-155.0   | 8.2                 | 6.8-8.8 | 29, 20, 30                |
| <i>Scirpus acutus</i> Muhl. ....                         | 122.5               | 17.1-220.0  | 19.8                | 0.0-1296.2  | 8.3                 | 7.2-9.1 | 79, 50, 90                |
| <i>S. americanus</i> Pers. ....                          | 190.0               | 87.7-277.0  | 28.0                | 3.0-1296.2  | 8.4                 | 7.4-8.9 | 9, 7, 14                  |
| <i>S. fluitans</i> (Torr.) Gray                          | 127.5               | 30.4-220.0  | 37.5                | 0.5-630.3   | 8.4                 | 7.0-9.1 | 42, 30, 53                |
| <i>S. heterochaetus</i> Chase                            | 121.1               | 41.2-198.7  | 48.4                | 11.5-282.0  | 8.1                 | 7.3-8.6 | 6, 5, 7                   |
| <i>S. paludosus</i> A. Nels. ....                        | 150.0               | 146.8-197.5 | 317.6               | 254.0-395.0 | 8.6                 | 8.4-9.0 | 3, 3, 5                   |
| <i>S. subterminalis</i> Torr. ....                       | 23.4                | 8.0-42.5    | .....               | .....       | 6.8                 | 6.8-7.5 | 6, .., 4                  |
| Araceae  |                     |             |                     |             |                     |         |                           |
| <i>Acorus Calamus</i> L. ....                            | 114.9               | 20.0-202.5  | 24.0                | 4.1-317.6   | 8.5                 | 7.3-8.8 | 14, 17, 17                |
| Lemnaceae  |                     |             |                     |             |                     |         |                           |
| <i>Lemna minor</i> L. ....                               | 135.7               | 41.2-262.5  | 36.5                | 0.0-254.0   | 8.2                 | 6.3-9.0 | 32, 23, 34                |
| <i>L. trisulca</i> L. ....                               | 134.4               | 41.2-297.5  | 17.0                | 0.0-332.0   | 8.2                 | 7.2-8.8 | 19, 15, 23                |
| <i>Spirodela polyrrhiza</i> (L.) Schleiden               | 130.8               | 49.0-297.5  | 28.0                | 1.0-619.2   | 8.2                 | 6.3-8.8 | 22, 14, 21                |
| <i>Wolffia columbiana</i> Karst. ....                    | 167.5               | 85.0-220.0  | 26.3                | 20.3-178.0  | 8.3                 | 7.2-8.4 | 7, 3, 6                   |
| Eriocaulaceae  |                     |             |                     |             |                     |         |                           |
| <i>Eriocaulon septangulare</i> With. ....                | 22.5                | 10.0-44.3   | 2.1                 | 0.0-5.8     | 7.5                 | 6.7-7.8 | 9, 4, 9                   |
| Pontederiaceae   |                     |             |                     |             |                     |         |                           |
| <i>Heteranthera dubia</i> (Jacq.) Mac M. ....            | 117.0               | 22.5-245.0  | 16.0                | 0.0-317.6   | 8.3                 | 7.6-9.0 | 41, 25, 36                |
| <i>Pontederia cordata</i> L. ....                        | 58.8                | 18.7-92.5   | .....               | 0.0-10.0    | 7.3                 | 7.2-7.9 | 4, 2, 3                   |
| Polygonaceae   |                     |             |                     |             |                     |         |                           |
| <i>Polygonum coccineum</i> Muhl. ....                    | 134.4               | 75.0-208.7  | 48.9                | 16.0-178.0  | 8.4                 | 7.7-8.8 | 5, 4, 5                   |
| <i>P. coccineum</i> Muhl., var. <i>rigidulum</i> Sheldon | 88.7                | 41.2-160.0  | .....               | 11.5-17.0   | 8.1                 | 7.3-8.4 | 7, 2, 9                   |
| <i>P. natans</i> A. Eaton, f. <i>genuinum</i> Stanf.     | 113.7               | 30.0-260.0  | 3.8                 | 2.8-282.0   | 8.2                 | 7.7-8.8 | 21, 16, 23                |
| Ceratophyllaceae   |                     |             |                     |             |                     |         |                           |
| <i>Ceratophyllum demersum</i> L. ....                    | 134.4               | 22.5-376.0  | 20.3                | 0.0-332.0   | 8.2                 | 6.3-9.0 | 85, 51, 93                |
| Nymphaeaceae   |                     |             |                     |             |                     |         |                           |
| <i>Brasenia Schreberi</i> Gmel. ....                     | 110.7               | 32.5-144.0  | 4.5                 | 0.0-6.0     | 8.4                 | 7.6-8.8 | 8, 4, 9                   |
| <i>Nuphar microphyllum</i> (Pers.) Fern. ....            | 22.5                | 7.5-41.1    | .....               | 0.5-6.0     | 6.8                 | 6.8-7.3 | 11, 6, 6                  |
| <i>N. rubrodiscum</i> Morong                             | 22.5                | 0.5-31.8    | .....               | 0.5-1.0     | 7.0                 | 6.8-7.3 | 5, 2, 6                   |
| <i>N. variegatum</i> Engelm. ....                        | 111.4               | 7.5-220.0   | 4.5                 | 0.0-178.0   | 8.0                 | 6.8-8.6 | 42, 23, 48                |

*N. rubrodiscum* Möröng ..... 22.5 0.5-31.8 ..... 7.0 6.8-7.3 ..... 5, 2, 6  
*N. variegatum* Engelm. .... 111.4 7.5-220.0 ..... 4.5 0.0-178.0 ..... 8.0 6.8-8.6 ..... 42, 23, 48

TABLE 1.—(Continued)

| Species   | Total Alkalinity    |             | Sulphate ion        |           | Hydrogen ion (pH)   |         | No. Analyses <sup>4</sup> |
|---|---------------------|-------------|---------------------|-----------|---------------------|---------|---------------------------|
|   | Median <sup>5</sup> | Range       | Median <sup>5</sup> | Range     | Median <sup>5</sup> | Range   |                           |
| <i>Nymphaea odorata</i> Ait. ....   | 63.4                | 37.5-162.5  | ...                 | 3.0-6.0   | 8.0                 | 7.6-8.4 | 4, 2, 4                   |
| <i>N. tuberosa</i> Paine .....  | 115.0               | 18.7-297.0  | 18.0                | 1.0-178.0 | 8.2                 | 6.3-9.0 | 31, 11, 38                |
| Ranunculaceae   |                     |             |                     |           |                     |         |                           |
| <i>Ranunculus longirostris</i> Godron .....                               | 126.8               | 113.2-144.0 | ...                 | 2.4-41.0  | 8.2                 | 7.9-8.4 | 3, 2, 3                   |
| <i>R. trichophyllus</i> Chaix .....                                       | 88.7                | 18.7-297.5  | 4.7                 | 0.5-36.4  | 8.2                 | 7.2-8.8 | 7, 6, 8                   |
| <i>R. trichophyllus</i> , var. <i>eradicatus</i> (Laedstadius) Drew ..... | 38.8                | 12.5-42.5   | ...                 | .....     | ...                 | 7.1-7.2 | 4, .., 2                  |
| Haloragidaceae  |                     |             |                     |           |                     |         |                           |
| <i>Hippuris vulgaris</i> L. ....  | 137.5               | 30.0-297.0  | 8.0                 | 0.5-199.2 | 8.4                 | 6.8-8.8 | 12, 7, 16                 |
| <i>Myriophyllum exalbescent</i> Fern. ....                                | 113.2               | 22.5-376.0  | 15.0                | 0.0-317.0 | 8.3                 | 7.2-8.9 | 68, 37, 72                |
| Lentibulariaceae  |                     |             |                     |           |                     |         |                           |
| <i>Utricularia intermedia</i> Hayne .....                                 | 113.7               | 8.0-245.0   | 3.0                 | 0.0-154.7 | 8.3                 | 7.7-8.6 | 11, 7, 10                 |
| <i>U. vulgaris</i> L., var. <i>americana</i> Gray .....                   | 144.0               | 16.5-297.5  | 8.8                 | 0.0-317.6 | 8.1                 | 6.8-8.8 | 29, 16, 33                |
| Lobeliaceae   |                     |             |                     |           |                     |         |                           |
| <i>Lobelia Dortmanna</i> L. ....  | 18.7                | 12.5-42.0   | ...                 | 0.0-10.2  | 7.2                 | 6.8-7.5 | 6, 2, 6                   |
| Compositae  |                     |             |                     |           |                     |         |                           |
| <i>Bidens Bechii</i> Torr. ....   | 90.6                | 31.8-190.0  | 6.0                 | 0.0-28.0  | 8.0                 | 7.0-8.8 | 19, 13, 18                |

<sup>3</sup> Total alkalinity is expressed as parts per million of CaCO<sub>3</sub> and sulphates as parts per million of the ion. The sum of the total alkalinity and sulphate ion times 1.6 gives an approximation of the total dissolved solid content for Minnesota waters having a total alkalinity greater than 50 parts per million.

<sup>4</sup> The number of analyses for each substance are presented in the same order as the analyses are listed in the table.

<sup>5</sup> Where there are an even number of analyses for total alkalinity or sulphate ion, the mean of the two central values is taken as the median. In even numbered pH series, the smaller of the two central numbers is taken as the median.

from five or more bodies of water from which they were taken. Other species for which fewer than five analyses are available are included in the discussion of the group or subgroup to which they probably belong. In most cases the nomenclature used agrees with Fassett (1940).<sup>6</sup>

#### GROUP I. THE SOFT-WATER FLORA

Members of the soft-water flora are most common and make their best growth in waters having a total alkalinity less than 40 parts per million, a sulphate ion concentration less than 5 parts per million, and a pH between 6.8 and 7.5. The most usual total alkalinity associated with these species in Minnesota is about 25 parts per million and the most usual pH about 7.2. Although the soft-water flora is characteristic of the Pre-cambrian rock region north of Lake Superior, it is found in the occasional soft-water ponds and outwash-plain lakes of central and northern Minnesota. The fibrous-rooted, rosette-forming species, *Lobelia Dortmanna* L., *Isoetes Braunii* Dur. and *Eriocaulon septangulare* With. are characteristic members of this flora. Modifications of the rosette or tuft growth form can be seen in other members of this flora such as *Sparganium fluctuans* (Morong) Robinson, *S. minimum* Fries, and *Scirpus subterminalis* Torr. Waterlilies tend to produce a more abundant growth of submerged juvenile leaves in soft waters than in hard waters and *Sagittaria latifolia* Willd. often develops only rosettes of phyllodes. As shown by Arber (1920), such aberrant growth is a result of poor growing conditions. Only a few species of submerged leafy-stemmed aquatic plants are common in soft water and these are usually of less robust growth than similar or related species of harder waters. Free-floating phanerogams are usually absent. As has been observed by Samuelsson (1925) and Thunmark (1931), soft-water lakes with mucky bottoms and brown water in which light penetration is poor have little submerged vegetation, the flora being largely limited to emergent and floating-leaved species. The depauperate growth of most typical soft-water species, as well as the comparative scarcity of aquatic plants in soft waters, suggests that the nature and fertility of the bottom soil is an important factor in determining the local distribution of plants suited to such waters. This has been demonstrated to be true for some soft-water lakes of England by Misra (1938).

Although the soft-water flora is most characteristic of low carbonate waters, the hydrogen ion concentration of these waters seems to be of greater importance in determining plant distribution than the concentration of carbonate salts. Members of the soft-water flora that can grow successfully in streams and boggy areas where the pH remains low throughout the summer tolerate carbonate concentrations considerably higher than are tolerated by species limited to lakes where the summer pH tends to increase with the carbonate content. McAtee (1939) considered several members of the soft-water flora to be plants of "acid" waters. In Minnesota this designation is true only in a

<sup>6</sup> The more important exceptions to Fassett's nomenclature are: *Potamogeton nodosus* Poiret = *P. americanus* C. & S.; *P. alpinus* Balbis = *P. tenuifolius* Raf.; *P. pusillus* L. = *P. panormitanus* Biv.; *P. Berchtoldi* Fieber = *P. pusillus* L.; *P. illinoensis* Morong includes *P. lucens* L.; *Phragmites communis* Trin. = *P. maximus* (Forsk.) Chiov.; *Ruppia occidentalis* S. Wats. = *R. maritima* L. in part.

general and comparative sense since these species are most common in waters that are neutral or slightly alkaline. That some of these species do tolerate markedly acid waters is shown by the data of Iversen (1929) who records *Lobelia Dortmanna* L. and *Myriophyllum alterniflorum* DC. from waters with a pH below 5.3. On the basis of ranges of chemical tolerance, the Minnesota soft-water flora can be separated into two sub-groups.

**Soft-water Subgroup 1.**—The species of this subgroup are largely limited to waters having a total alkalinity of less than 40 parts per million, a sulphate ion concentration less than 5 parts per million, and a pH less than 7.5. They are mostly plants of lakes and ponds. The commonest and most characteristic species are *Isoetes Braunii* Dur., *Sparganium angustifolium* Morong, *Potamogeton Spirillus* Tuckerm., *Scirpus subterminalis* Torr., *Eriocaulon septangulare* With., and *Lobelia Dortmanna* L.

Species probably belonging to this subgroup, but concerning which fewer data are available, are *Isoetes marospora* Dur., *Sparganium angustifolium* Michx., *S. minimum* Fries, *Najas gracillima* (A. Br.) Magnus, *Nymphaea Leibergii* Morong, *Ranunculus trichophyllus* Chaix, var. *eradicatus* (Laedstadius) Drew, *Callitriche hermaphrodita* L., *Elatine minima* (Nutt.) Fisch. and Mey., *Myriophyllum alterniflorum* DC., *M. Farwellii* Morong, *M. tenellum* Bigel., and *Littorella americana* Fern.

**Soft-water Subgroup 2.**—This subgroup includes species that are most common in the waters defined for Soft-water Subgroup 1 but which also range into harder water in streams and boggy areas where the pH remains low. They are seldom found in waters with a total alkalinity greater than 150 parts per million and a pH above 7.7. The principal species of this subgroup are *Potamogeton epiphydrus* Raf., *P. gramineus* L., var. *graminifolius* Fries, *P. alpinus* Balbis, *Calla palustris* L., *Glyceria borealis* (Nash) Batchelder, *Nuphar microphyllum* (Pers.) Fern., *N. rubrodiscum* Morong, *Potentilla palustris* (L.) Scop., *Callitriche palustris* L., and *Myriophyllum verticillatum* L.

Probably also belonging to this subgroup are *Potamogeton Berchtoldi* Fieber, *P. obtusifolius* Mert. & Koch, and *Glyceria neogaea* Steud.

## GROUP II. THE HARD-WATER FLORA

The hard-water flora is typical of the lakes and streams of the calcareous gray glacial drift that covers a large portion of the state. The chemical conditions most frequently associated with this flora can be summarized as follows: Total alkalinity 90 to 150 parts per million, sulphate ion 5 to 40 parts per million, and summer pH of surface waters 8.0 to 8.8. Although all the species of this flora make their best growth in these waters, the individual species show different degrees of tolerance to carbonate and sulphate salts. Many of the members of this flora do not occur in waters having a total alkalinity of less than 30 parts per million, and nearly all are infrequent and make poor growth in waters having a total alkalinity of less than 20 parts per million. A sulphate ion concentration of 50 parts per million marks the upper limit of tolerance of a considerable number of these species, and few were taken from waters with a sulphate ion concentration greater than 300 parts per million.

Hard-water lakes usually have a dense marginal zone of *Chara* spp., *Potamogeton* spp., *Najas flexilis* (Willd.) R. & S., *Anacharis canadensis* (Michx.) Planchon, *Ceratophyllum demersum* L., and *Myriophyllum exalbesces* Fern. that often extends to a water depth of 8 to 10 feet. On mucky bottoms *Nuphar variegatum* Engelm., and *Nymphaea tuberosa* Paine are common. Along shores the most abundant emergent species are *Phragmites communis* Trin., *Scirpus validus* Vahl., *S. acutus* Muhl., and *Typha latifolia* L. Throughout the northern half of the state *Zizania aquatica* L. forms fringing stands along the shores of deeper lakes and in many places fills shallow, mucky-bottomed lakes to the exclusion of other emergent species (Moyle, 1944). In quiet waters over fertile bottoms *Lemna minor* L., *L. trisulca* L., and *Spirodela polyrrhiza* (L.) Schleid. are often abundant as is *Utricularia vulgaris* L., var. *americana* Gray. Submerged rosette- and tuft-forming species which are characteristic of soft waters are generally lacking from hard waters, the only notable exception being *Vallisneria americana* Michx. Submerged species with elongate stems such as *Potamogeton* spp. and *Myriophyllum* spp. are more abundant and of more robust growth in hard waters than similar and related species of soft waters. As the sulphate ion concentration increases, the numbers of species occurring is considerably reduced and lakes intermediate between hard carbonate and alkali waters frequently have a flora of only 7 or 8 species, the most common of which are *Potamogeton pectinatus* L., *P. Richardsonii* (Benn.) Rydb., *P. foliosus* Raf., *Ceratophyllum demersum* L., and *Scirpus fluviatilis* (Torr.) Gray.

The Minnesota hard-water flora is generally comparable to that recorded by Samuelsson (1925) for the "Potamogeton lakes" of Sweden and similar to the flora of the "fresh-water lakes" of North Dakota reported by Metcalf (1931). It is the "calcareous" water flora of McAtee (1939). Iversen (1929) found a similar flora in the more calcareous lakes of Denmark and noted that among the more common and characteristic species were *Potamogeton pectinatus* L., *P. natans* L., and *Ceratophyllum demersum* L., three species also typical of the Minnesota hard-water lakes.

*Hard-water Subgroup 1.*—The species of this subgroup are common over the total alkalinity range of Minnesota waters above 40 parts per million and occur less frequently below this concentration with the members of the soft-water flora. These members of this subgroup are usually lacking from waters with a sulphate ion concentration greater than 50 parts per million. Species that are least tolerant to low concentrations of carbonate salts and which have not been taken from waters with a total alkalinity of less than 30 parts per million are starred (\*).

Typical of this subgroup are *Potamogeton amplifolius* Tuckerm., \**P. Friesii* Rupr., \**P. gramineus* L., var. *graminifolius* Fries, f. *myriophyllum* (Robbins) House, \**P. illinoensis* Morong, *P. natans* L., \**P. pusillus* L., *P. strictifolius* Benn., *Sagittaria cristata* Engelm., *S. rigida* Pursh, \**Anacharis canadensis* Michx., *Glyceria grandis* Wats., \**Leersia oryzoides* (L.) Swartz, and *Zizania aquatica* L., var. *angustifolia* Hitchc.

*Hard-water Subgroup 2.*—This subgroup includes species that are usually

lacking from waters with a total alkalinity of less than 30 parts per million and which commonly occur in waters with a sulphate ion concentration greater than 50 parts per million. All the following species have been taken from waters with a sulphate ion concentration greater than 75 parts per million and the starred (\*) species from waters with a sulphate ion concentration greater than 250 parts per million.

Typical of this subgroup are *Sparganium eurycarpum* Engelm., *Potamogeton nodosus* Poir., \**P. foliosus* Raf., \**P. Richardsonii* (Benn.) Rydb., \**P. pectinatus* L., \**Zannichellia palustris* L., var. *major* (Boenn.) Koch, \**Najas guadalupensis* (Spreng.) Morong, *Alisma Plantago-aquatica* L., *Zizania aquatica* L., *Scirpus americanus* Pers., *S. validus* Vahl., *S. heterochaetus* Chase, \**S. fluviatilis* (Torr.) Gray, \**Lemna minor* L., \**L. trisulca* L., \**Spirodela polyrrhiza* (L.) Schleid., *Wolffia columbiana* Karst., \**Polygonum natans* A. Eaton, var. *genuinum* Stanf., *P. coccineum* Muhl. and *Hippuris vulgaris* L.

*Potamogeton pectinatus*, *Zannichellia palustris*, var. *major*, and *Scirpus americanus*, all are known from the data of Metcalf (1931) to range into more alkali waters than are found in Minnesota. The other species of this subgroup appear to be largely limited to waters with a sulphate ion concentration less than 300 parts per million.

**Hard-water Subgroup 3.**—This subgroup includes aquatic plants that make their best growth and are most abundant in hard waters but which range into both soft and alkali waters. All the highly tolerant members of this subgroup have been taken from waters with a total alkalinity of less than 40 parts per million and a sulphate ion concentration greater than 150 parts per million. They are usually infrequent and make poor growth in waters with a total alkalinity of less than 20 parts per million or in waters with a sulphate ion concentration greater than 300 parts per million. The starred (\*) species show the greatest tolerance to sulphate salts and have been taken from waters with a sulphate ion concentration greater than 350 parts per million.

Typical of this subgroup are \**Typha latifolia* L., *Potamogeton praelongus* Wolf., *P. zosteriformis* Fern., *Najas flexilis* (Willd.) R. & S., *Sagittaria latifolia* Willd., *S. cuneata* Sheldon, *Vallisneria americana* Michx., \**Phragmites communis* Trin., \**Eleocharis palustris* (L.) R. & S., *E. acicularis* R. & S., \**Scirpus acutus* Muhl., *Acorus Calamus* L., *Heteranthera dubia* (Jacq.) MacM., *Ceratophyllum demersum* L., *Myriophyllum exalbescent* Fern., *Utricularia vulgaris* L., var. *americana* Gray, *Anacharis occidentalis* (Pursh) Vic-torin, *Nymphaea tuberosa* Paine, and *Nuphar variegatum* Engelm.

**Other Hard-water Species.**—In addition to the hard-water aquatic plants already considered, there are a number of species that because of their infrequent occurrence or unusual distribution cannot be placed into the foregoing subgroups. Most of these species have been taken only from waters with a total alkalinity greater than 100 parts per million and a sulphate ion concentration of less than 50 parts per million. They include the flora of the hard-water streams of southeastern Minnesota in which the commonest species are *Nasturtium officinale* Cov., *Veronica americana* Schwein., and *Ranunculus longirostris* Godron. These species are most common in running waters with a total



alkalinity greater than 150 parts per million and occur elsewhere along with *Mimulus glabratus* HBK., var. *Fremontii* (Benth.) Grant in the vicinity of springs. *Nelumbo lutea* L., because of its slow migration, has apparently not reached many waters that seem to be suited to it. *Potamogeton crispus* L., a European species, was introduced into Minnesota about 1910 and is still extending its distributional range. *Potamogeton vaginatus* Turcz., *P. filiformis* Pers., var. *borealis* (Raf.) St. John, and *Veronica connata* Raf. are also members of the hard-water flora.

Another group of species has a chemical preference that appears to be intermediate between the typical members of the hard- and soft-water floras. They are largely plants of mucky-bottomed lakes and streams and sometimes of sandy lake shores. The most usual total alkalinity associated with these species in Minnesota is around 60 parts per million, and the most usual pH is 8.0. They are usually not found in waters with a total alkalinity greater than 150 parts per million and are more frequently associated with members of soft-water flora, especially Soft-water Subgroup 2, than with members of the hard-water flora.

Typical members of this group are *Equisetum fluviatile* L., *Sparganium chlorocarpum* Rydb. and its var. *acaule* (Beeby) Fern., *Potamogeton Robbinsii* Oakes, *Eleocharis palustris* L., var. *major* Sonder, *Pontederia cordata* L. and *Nymphaea odorata* Ait.

#### GROUP III. THE ALKALI-WATER FLORA

The alkali-water flora inhabits those lakes of southwestern and extreme western Minnesota that are characterized by a high concentration of both carbonate and sulphate salts. Such waters are the "alkaline" waters of McAtee (1939) and the "alkali" waters of Metcalf (1931). Members of the alkali-water flora do not occur in waters with a sulphate ion concentration of less than 50 parts per million and are most frequent in waters with a sulphate ion concentration greater than 125 parts per million and a pH between 8.4 and 9.0.

Typical of this group are *Ruppia occidentalis* S. Wats., *Najas marina* L. and *Scirpus paludosus* A. Nels. Other species that probably belong here are *Typha angustifolia* L., *Juncus Torreyi* Coville, *Alisma gramineum* Gmel., var. *Geyeri* (Torr.) Samuelsson, and *Fluminea festuacea* (Willd.) Hitchc. Two other species, *Potamogeton pectinatus* L. and *Zannichellia palustris* L., var. *major* (Boenn.) Koch, are frequently associated with the typical alkali-water flora, but since they are also characteristic of the harder carbonate waters they have been considered with that group.

A comparison of the Minnesota data with those of Metcalf (1931) for the alkali lakes of North Dakota suggests that the maximum salt concentrations found for *Najas marina* and *Zannichellia palustris* in Minnesota is near the maximum for central North America. On the other hand, *Ruppia occidentalis*, *Potamogeton pectinatus*, and *Scirpus paludosus* are known to tolerate concentrations of alkali salts that are much higher than those found in Minnesota waters (Huntsman, 1922; St. John and Courtney, 1924; Young, 1924; Metcalf, 1931).

## Experimental Growth of Some Aquatic Plants

During the winter of 1937 three species of aquatic plants of limited natural distribution and chemical tolerance were grown experimentally in five lake waters of different chemical composition to observe the effect of water chemistry upon growth and survival. The plants used were: *Lobelia Dortmanna* L., a typical soft-water species; *Ruppia occidentalis* S. Wats., a typical alkali-water species; and *Lemna minor* L., a free-floating species that is largely limited to hard-water and alkali lakes. The five lakes from which water and bottom soil were used are: (1) Big Lake, Carlton County, a clear, soft-water lake with a total alkalinity of 20.0 parts per million, a sulphate ion concentration of 2.0 parts per million, a pH of 7.2, and a bottom of red sand containing little organic material; (2) Farley Lake, Itasca County, a brown-water bog lake with a total alkalinity of 53.0 parts per million, a sulphate ion concentration of 2.0 parts per million, a pH of 6.8, and a bottom of semi-fluid muck; (3) Snail Lake, Ramsey County, a clear hard-water lake with a total alkalinity of 162.0 parts per million, a sulphate ion concentration of 5.0 parts per million, a pH of 8.7, and a bottom of calcareous sand mixed with organic material; (4) Dead Coon Lake, Lincoln County, an alkali prairie lake with a total alkalinity of 192.5 parts per million, a sulphate ion concentration of 215.6 parts per million, a pH of 8.8, and a bottom of black, granular organic soil, and (5) Big Stone Lake, Big Stone County, an alkali lake with a total alkalinity of 167.5 parts per million, a sulphate ion concentration of 317.6 parts per million, a pH of 8.6, and a bottom of sand mixed with rich calcareous organic soil.

Thirty two-gallon battery jars were obtained. These were separated into five series of six jars each, each series representing a single lake. Three jars of each lake series received three inches of the natural bottom soil of the lake, and the remaining three jars of the same series received three inches of washed white St. Peter sand. After the bottom soil was supplied, six quarts of water were added to each jar from the lake of which the series of jars was representative. When the jars of all five lake series had been so prepared they were placed on a well-lighted table in the tropical room of the University of Minnesota Greenhouse. The jars were covered with glass plates and allowed to stand for two weeks to let the water clarify. At the end of this time plantings were made. A jar with natural bottom and one with washed sand in each lake series were planted with six *Lobelia* plants, two similar jars with six *Ruppia* sprigs, and two with six *Lemna* colonies. All plants were rooted and in good condition. Before planting, the net weight of each group of six *Lobelia* and *Ruppia* plants was determined and the number of leaves counted. The total number of *Lemna* fronds was determined for each jar and their condition noted.

The plants were allowed to grow for 11 weeks. During the first 4 weeks the plants were supplied artificial light for 12 hours a day and for the last 7 weeks received artificial light continuously. The plants were observed each week, their condition noted, and enough distilled water added to maintain initial levels. Water analyses run on the jars during the course of the experiment showed that although some divergence from the original analyses

occurred, the jar series maintained the same general relationship to one another as the lakes that supplied the water and soil.

At the end of 11 weeks when the experiment was terminated, the plants were removed, counted, and weighed and their general condition noted. From the data presented in Table 2 and observations made during the course of the experiment, the following statements can be made:

(1) *Lobelia* plants survived for 11 weeks on washed sand in all 5 lake waters but showed an increase in weight only in the soft water and on the natural red sand of Big Lake. Although *Lobelia* plants remained in good condition, they just maintained their initial weight on washed sand in the moderately hard-water of Farley Lake. In all other waters they lost weight and produced small chlorotic leaves. The number of leaves produced was about the same in all water types but root growth was in inverse proportion to the salt concentration. All plants died in the organic soils of Farley and Dead Coon lakes.

(2) *Ruppia* plants remained green on washed sand in all types of waters but failed to show significant growth in any of them. Good growth was made only in sulphate waters on soils containing organic material. It is of interest to note that better growth was made upon the organic soil of Farley Lake than on the sand-organic-marl soil of Snail Lake despite the lower salt concentration of Farley Lake.

(3) The number of *Lemna* fronds either showed only a slight increase during the first weeks or declined throughout the course of the experiment in all jars except in the water and over the rich organic bottom of Dead Coon Lake. Although the fronds remained in good condition longer in soft than in hard waters, no appreciable growth occurred in any of the waters over washed sand.

#### Effect of Other Factors

Within the range of chemical tolerance the local distribution of aquatic plants is greatly influenced by the type of bottom soil and the physical nature of the body of water. Most members of the Minnesota aquatic flora make their best growth on mixtures of organic soil and sand. Some, such as *Lobelia Dortmanna*, show a definite preference for sand. The most common plants of soft organic soils are *Zizania aquatica*, *Pontederia cordata*, *Ceratophyllum demersum*, *Najas flexilis*, the water lilies, and *Potamogeton zosteriformis* and related narrow-leaved pondweeds. Marl bottoms frequently have a flora limited to *Chara* spp., depauperate *Najas flexilis* and *Potamogeton pectinatus*. This last species is frequently the only inhabitant of calcareous river silts.

Compared to the varied flora of the Minnesota lakes, the number of species making successful growth in streams is quite small. In the larger rivers the commonest submerged plants are *Potamogeton nodosus*, *P. pectinatus*, *Vallisneria americana*, *Heteranthera dubia*, and *Anacharis canadensis*. In quiet pools and backwaters the water lilies, especially *Nymphaea tuberosa* and *Nuphar variegatum*, often occur. The most common submerged species of the small streams in northeastern Minnesota are the water moss, *Fontinalis gigantea* Sulliv., and the water-star-wort, *Callitriche palustris*, and the pondweeds, *Pota-*

TABLE 2.—Experimental growth<sup>9</sup> of *Lobelia Dortmanna* L. and *Ruppia occidentalis* S. Wats. in two-gallon battery jars containing natural lake water of different chemical quality and bottom soils of different types.

| L a k e s         | Lobelia       |     |                 |      |                   |      | Ruppia      |     |                 |     |                   |      |
|-------------------|---------------|-----|-----------------|------|-------------------|------|-------------|-----|-----------------|-----|-------------------|------|
|                   | No. of plants |     | Ave. no. leaves |      | Ave. wt. cms. 1.1 |      | Root length |     | Ave. no. leaves |     | Ave. wt. cms. 1.1 |      |
|                   |               |     |                 |      |                   |      |             |     |                 |     |                   |      |
|                   | Begin         | End | Begin           | End  | Begin             | End  | Begin       | End | Begin           | End | Begin             | End  |
| Big Lake          |               |     |                 |      |                   |      |             |     |                 |     |                   |      |
| Natural soil      | 6             | 6   | 8.7             | 14.0 | 0.56              | 0.65 | 9.0         | 6   | 5               | 3.5 | 0.11              | 0.08 |
| St. Peter sand 10 | 6             | 6   | 7.0             | 12.6 | 0.41              | 0.39 | 7.0         | 6   | 6               | 4.1 | 0.11              | 0.15 |
| Farley Lake       |               |     |                 |      |                   |      |             |     |                 |     |                   |      |
| Natural soil      | 6             | 0   | 7.9             | 0.0  | 0.41              | 0.0  | 0.0         | 6   | 5               | 4.1 | 0.13              | 0.33 |
| St. Peter sand    | 6             | 6   | 6.6             | 11.6 | 0.48              | 0.48 | 7.0         | 6   | 6               | 4.5 | 0.12              | 0.29 |
| Snail Lake        |               |     |                 |      |                   |      |             |     |                 |     |                   |      |
| Natural soil      | 6             | 5   | 6.6             | 13.0 | 0.43              | 0.26 | 1.7         | 6   | 5               | 4.9 | 0.08              | 0.25 |
| St. Peter sand    | 6             | 6   | 9.1             | 15.6 | 0.52              | 0.43 | 4.4         | 6   | 6               | 4.0 | 0.18              | 0.23 |
| Dead Coon Lake    |               |     |                 |      |                   |      |             |     |                 |     |                   |      |
| Natural soil      | 6             | 0   | 0.0             | 0.0  | 0.0               | 0.0  | 0.0         | 6   | 1               | 3.5 | 0.11              | 1.40 |
| St. Peter sand    | 6             | 6   | 6.6             | 13.6 | 0.45              | 0.22 | 2.0         | 6   | 4               | 6.5 | 0.12              | 0.22 |
| Big Stone Lake    |               |     |                 |      |                   |      |             |     |                 |     |                   |      |
| Natural soil      | 6             | 2   | 7.5             | 7.0  | 0.47              | 0.38 | 1.5         | 6   | 4               | 4.3 | 0.12              | 0.75 |
| St. Peter sand    | 6             | 6   | 6.6             | 12.6 | 0.40              | 0.21 | 0.6         | 6   | 6               | 3.1 | 0.12              | 0.17 |

<sup>7</sup> See text for description of water chemistry and soils.

<sup>8</sup> Average length of longest roots of all surviving plants at the termination of the experiment.

<sup>9</sup> Results after 11 weeks growth.

<sup>10</sup> St. Peter sand is nearly pure  $S_1O_2$  containing traces of iron.

<sup>11</sup> Wet weight after excess water was removed with paper towels.

*mogeton alpinus* and *P. gramineus* var. *graminifolius*. *Sparganium chlorocarpum* is often common in slow stretches. The flora of the small spring-fed streams of southeastern Minnesota is largely limited to *Ranunculus longirostris*, *Nasturtium officinale*, and *Veronica connata*. Aside from such semi-aquatic plants as the members of the genera *Carex* and *Eleocharis*, the most common emergent plants in streams are the bulrushes, *Scirpus fluviatilis* and *S. acutus*. In the northern half of the state wild rice, *Zizania aquatica*, the northern manna grass, *Glyceria borealis*, the water plantain, *Alisma Plantago-aquatica*, and the arrowheads, especially *Sagittaria rigida*, occur in shallow water along stream margins. In the southern portion of the state the grasses, *Leersia oryzoides* and *Spartina pectinata*, and the smartweed *Polygonum cocineum*, are common in similar situations.

### Summary and Conclusions

1. The Minnesota aquatic flora can be separated on the basis of water quality tolerance and preference into three major groups: The soft-water flora, the hard-water flora, and the alkali- or sulphate-water flora. Within these groups subgroups can be constructed on the basis of the chemical tolerance of the individual species.

2. On the basis of chemical data from 225 bodies of water and the correlated distribution of the more common species of aquatic plants in Minnesota, the waters of the state can be classified as follows: Soft waters—those waters with a total alkalinity of less than 40 parts per million, a sulphate ion concentration of less than 5 parts per million, and a pH below 7.4; hard waters—those waters with a total alkalinity usually between 90 and 250 parts per million, a sulphate ion concentration usually below 50 parts per million, and a summer pH between 8.0 and 8.8; and alkali or sulphate waters—those waters with a total alkalinity greater than 150 parts per million, a sulphate ion concentration usually greater than 125 parts per million, and a summer pH between 8.4 and 9.2.

3. Although the soft-water flora is most characteristic of waters with a total alkalinity below 40 parts per million, a number of species range into harder waters in situations where the pH remains low. This suggests that pH is a more important factor in limiting the distribution of this group of plants than the dissolved mineral content of the water. The usual upper tolerance limit of this group is a total alkalinity of 50 parts per million in lakes and 150 parts per million in streams and boggy areas where the pH remains below 7.6. Experimental growth of *Lobelia Dortmanna* L., a typical soft-water species, shows that hard waters with a high pH and alkali waters definitely inhibit its growth.

4. The hard-water flora consists of a large and varied group of aquatic plants that are most typical of waters with a total alkalinity of 90 to 250 parts per million and with a sulphate ion concentration less than 50 parts per million. The summer pH of the hard waters associated with these species commonly ranges from 8.0 to 8.8. Most of the hard-water species make a poor growth or are lacking from waters with a total alkalinity of less than 30 parts per million. Although 50 parts per million is the upper limit of sulphate ion toleration for some of the hard-water species, others range into waters with

concentrations as high as 300 parts per million. This concentration seems to be about the upper limit of tolerations for nearly all the hard-water species. The concentration of sulphate salts seems to be more effective in limiting distribution than the concentration of carbonate salts. Although most hard-water species tolerate a range of carbonate ion of 120 parts per million (total alkalinity 200 parts per million), some of these same plants tolerate a range of only 50 parts per million of sulphate ion.

5. The alkali or sulphate-water flora is largely limited to Minnesota waters with a total alkalinity greater than 150 parts per million, a sulphate ion concentration greater than 50 parts per million, and a pH between 8.4 and 9.2. This flora is characteristically developed in waters with a sulphate ion concentration greater than 125 parts per million. The upper limit of sulphate ion tolerance for these species cannot be safely estimated because of the limited series of sulphate waters in Minnesota, but such species as *Najas marina* L. and *Zannichellia palustris* L.; var. *major* are known to tolerate a concentration of 1,290 parts per million of sulphate ion in Minnesota. Other species such as *Ruppia occidentalis* S. Wats. and *Potamogeton pectinatus* L. have been shown to tolerate much higher concentrations of sulphates in more arid regions. Experimental growth of *Ruppia* suggests that hard and soft carbonate waters are not toxic to this species, but that in such waters the plants are unable to gain sufficient nutriment for successful growth.

6. Although water chemistry appears to be the most important single factor influencing the general distribution of aquatic plants in Minnesota, field observations show that the type of bottom soil and the physical nature of the body of water greatly influence the local distribution of a species within its range of chemical tolerance. Experimental growth studies with *Lemna minor* suggest that even free-floating vegetation is dependent upon the fertility of the bottom soil for successful growth.

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## Estimations of Volumes, Surface Areas, and Numbers of Twig Crotches in Elm Trees

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In work<sup>2</sup> connected with the Dutch elm disease data were collected from which cubic volumes, square feet of bark area, and numbers of twig crotches in elm trees were computed. These data were collected from American elm, *Ulmus americana* L., trees of different sizes and from various locations. The importance of the knowledge of tree volumes is of value, for example, in computing the number of trees necessary for given volumes, amount of lumber or wood products in trees of given diameters, costs of tree transportation, and also the labor of cutting or line clearing. The knowledge of the area of the bark of trees of different sizes may be applied to compute the amount of toxicants, repellent sprays, or other chemical dosages needed for treatment against insects or other organisms, and to aid in measuring the amount of beetle infestations in trees. Knowledge of bark areas, and of the number of twig crotches may also aid in understanding more about Dutch elm disease infections, phloem necrosis, and other diseases, or insect incidences.

### Methods and Materials

Selection of areas or locations for securing tree volumes or bark area measurements depended on the availability or opportunity for cutting trees. The trees were cut and examined for purposes other than taking the data herein reported, and hence the results are considered as secondary to the primary objective. The trees were cut in areas secured through cooperation with the New Jersey State Department of Agriculture. The locations and trees were selected in woodland tracts where tree values were negligible. Cubic volumes and bark areas of such tree populations are not, however, believed to differ much from other tree populations, except possibly those in exceptionally heavy shade.

Selections of trees were limited to those on given properties and were often based on convenience in felling individual trees. Larger trees were often selected because they were more likely to harbor beetle infestations.

Random samples which comprised one-sixth of each tree were examined. Each tree sampled was divided, theoretically, from ground level up to branches one inch in diameter, into sections each six feet long. Branches smaller than one inch were not sampled, since, as shown by Baker (1940), elm bark beetles breed in such small branches so infrequently. By means of dice throws a single linear foot of each section was selected for examination. Mid-diameter measurements, made to the nearest half inch, outside of bark, and the constant

<sup>1</sup> Formerly with the Dutch Elm Disease Eradication Project, U. S. Bureau of Entomology and Plant Quarantine.

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linear length, one foot, were used to calculate volumes and bark areas of each section. Since one-sixth of each tree was examined, a simple multiplication of the volume or of the area figure by six gave an approximation of the volumes and bark areas of each tree.

The smallest and largest trees recorded were 3 and 21½ inches d.b.h., (diameter at breast height), respectively. Size classes were established, dividing the trees into classes with one inch intervals. Unequal numbers of trees were sampled at the six different locations included in this study.

Statistical analyses were made of the data according to methods outlined by Snedecor (Chap. 12, 1940,) after the observed values were seen to follow straight line trends by logarithmic transformations.

### Cubic Volume Content

Examinations of from 9 to 155 trees in each of six township locations in Northern New Jersey, (totaling 218 trees) gave data on which these volume figures are based. Several and wide spread differences in soil types and other factors are believed represented by the various locations. The trees were principally woodland, mostly of the closed-grown type. Growth sites of trees examined appeared to cause no differences, and attempts to classify the trees according to whether they were closed- or open-grown, although not extensive, indicated no perceptible differences. Closed-grown trees, which are generally taller than those grown in the open, appeared to have compensated for the broader and shorter configuration of the latter type by increased heights.

Tree volumes increased markedly with tree d.b.h. increases as shown in table 1. Graphic studies showed rather sharp curve inclinations denoting rapid volume increases as the diameters increase when the data were plotted by uniform graph spacing, but the increase was linear when plotted by logarithmic graph spacing. Relationships between the different locations, the different tree size classes, and the rates of volume increase are shown graphically in fig. 1, which is logarithmically spaced.

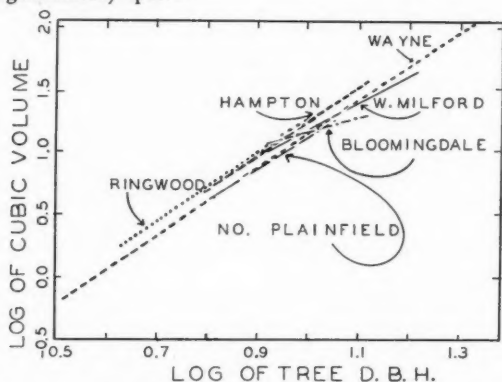


Fig. 1. Regression of cubic feet volume of elm trees on diameters.

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TABLE 1.—Average number of cubic feet of wood in elm trees.  
Tree diameter classes, inches d. b. h.

| Township             | 3 1/4 | 4 1/4 | 5 1/4 | 6 1/4 | 7 1/4 | 8 1/4 | 9 1/4 | 10 1/4 | 11 1/4 | 12 1/4 | 13 1/4 | 14 1/4 | 15 1/4 | 16 1/4 | 17 1/4 | 18 1/4 | 19 1/4 | 20 1/4 | 21 1/4 |
|----------------------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Ring-wood            | 0     | 3     | 1     | 0     | 0     | 2     | 3     | 6      | 1      | 0      |        |        |        |        |        |        |        |        |        |
| Wayne                | 0.8   | 1.2   | 2.5   | 3.2   | 5.9   | 8.9   | 11.0  | 15.4   | 15.9   | 23.9   | 51.3   | 35.7   | 49.4   | 50.2   | 67.9   | ....   | 80.9   | 86.3   | 79.8   |
|                      | 12    | 17    | 15    | 23    | 20    | 11    | 16    | 4      | 8      | 8      | 1      | 2      | 6      | 7      | 4      | 0      | 1      | 1      | 1      |
| Hampton              | 0     | 0     | 0     | 3     | 3     | 1     | 4     | 1      | 0      | 4      | 0      |        |        |        |        |        |        |        |        |
|                      | 0     | 0     | 0     | 3     | 3     | 1     | 4     | 1      | 0      | 4      | 0      |        |        |        |        |        |        |        |        |
| North Plainfield     | 0     | 1     | 0     | 1     | 3     | 1     | 0     | 0      | 0      | 2      | 0      | 0      | 1      |        |        |        |        |        |        |
|                      | 0     | 1     | 0     | 1     | 3     | 1     | 0     | 0      | 0      | 2      | 0      | 0      | 1      |        |        |        |        |        |        |
| West Milford         | 0     | 0     | 0     | 0     | 0     | 1     | 3     | 3      | 0      | 2      | 0      | 1      | 0      | 1      |        |        |        |        |        |
|                      | 0     | 0     | 0     | 0     | 0     | 1     | 3     | 3      | 0      | 2      | 0      | 1      | 0      | 1      |        |        |        |        |        |
| Bloom- ingdale       | 0     | 0     | 0     | 0     | 0     | 2     | 3     | 3      | 1      | 0      | 0      | 1      | 1      |        |        |        |        |        |        |
|                      | 0     | 0     | 0     | 0     | 0     | 2     | 3     | 3      | 1      | 0      | 0      | 1      | 1      |        |        |        |        |        |        |
| Total trees examined | 12    | 21    | 16    | 27    | 26    | 18    | 29    | 17     | 10     | 16     | 1      | 4      | 8      | 8      | 4      | 0      | 1      | 1      | 1      |

Close parallelism of the regression lines is indicated in fig. 1. This suggests that locations, growth characteristics and soil types have little effect on tree volumes measured by d.b.h. units. In tests for significance the analyses showed: (1) four regression coefficients were significantly different from zero, (2) that adjusted d.b.h. classes varied significantly more than trees within locations, (3) the regression coefficients for locations are nearly alike, (4) the average regression is the best estimate of the population regression, the formula of which is as follows:

expected number of cubic feet, in logarithms =  $2.5699 (\log x) - 1.4228$ , and (5) the coefficient of correlation is  $r = +.9798$ .

Cubic volume contents of elm trees, shown above to have increased directly by logarithmic transformations, were considered possibly to increase according to some other, and more simple function. Cubing the d.b.h. size was suggested. Slight curvatures, not straight line increases, resulted when this was done. The  $t$  values, moreover, were lower, almost statistically significantly lower, than by logarithmic transformations. The  $t$  values individually were significant, however, with the exception that the data from the Bloomingdale location was again insignificant from zero.

Summarization of the cubic contents is made by the regression formula given above. Computations of expected logarithmic numbers were made and after conversions of the logarithms into cubic feet the results are given in table 2.

Evaluations of the number of elm trees required to produce a cord of wood are also given in table 2. These estimates were computed from factors given by Green (1903) on the number of cubic feet of wood in cord measures. Since different diameters of logs affect somewhat the number of cubic feet of wood per cord, and since no attempt is made to isolate this factor these figures are presented as estimates.

### Tree Surface Areas

Trees in the locations described above for volume content were used for computing surface areas. The average numbers of square feet of bark areas per tree in each diameter size class, for each location, and the number of trees on which each average is based are shown in table 3.

Comparatively rapid rates of bark area increase with tree d.b.h. size increase are shown in table 3. Each increase in size is associated with an increase in surface area.

Straight line trends were evident by plotting the averages on logarithmic spaced graph spacing. Squaring the d.b.h. met with the same objections as cubing the d.b.h. for volume, e.g.; wider differences between the calculated and observed values.

Regression or smoothed lines were calculated from the averages in table 3, for each location. These lines, showing the comparative relationships of the averages for locations and tree sizes are presented in fig. 2.

In general the regression lines lie comparatively close together, interpreted as showing that locations affect little the surface areas of trees. Parallelism of four of the regression lines shows that, except for Bloomingdale and West

TABLE 2.—Estimated cubic feet of wood in elm trees, and approximate number of trees per cord.

|                                      | Tree diameter classes, inches d. b. h. |       |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
|--------------------------------------|--|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                                      | 3 1/4                                  | 4 1/4 | 5 1/4 | 6 1/4 | 7 1/4 | 8 1/4 | 9 1/4 | 10 1/4 | 11 1/4 | 12 1/4 | 13 1/4 | 14 1/4 | 15 1/4 | 16 1/4 | 17 1/4 | 18 1/4 |
| Cu. ft. per tree*                    | 0.8                                    | 1.6   | 2.7   | 4.2   | 6.4   | 8.6   | 11.5  | 15.0   | 19.0   | 23.6   | 28.9   | 34.9   | 41.5   | 48.9   | 57.0   | 65.9   |
| No. trees @ 85.84 cu. ft. per cord † | 107.3                                  | 53.7  | 32.0  | 20.4  | 13.4  | 10.0  | 7.5   | 5.7    | 4.5    | 3.6    | 3.0    | 2.5    | 2.1    | 1.8    | 1.5    | 1.3    |
| No. trees @ 69.67 cu. ft. per cord † | 87.1                                   | 43.5  | 25.8  | 16.6  | 10.9  | 8.1   | 6.1   | 4.6    | 3.7    | 3.0    | 2.4    | 2.0    | 1.7    | 1.4    | 1.2    | 1.1    |

\* Computed from the formula,

Log of expected number of cu. ft. of wood per tree = 2.5699 (log. of d.b.h.) — 1.4228, and converted back to numbers.

† The factor 85.84 cubic feet of wood per cord appears to be near the ordinary amount of wood; per cord, and 69.67 cubic feet of wood per cord appears, from the discussion by Green (1903), to be near the amount of smaller wood pieces to give cord measures.

TABLE 3.—Average number of square feet of bark areas in elm trees of different diameters.

| Location          | Tree diameter classes, inches d. b. h. |       |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
|-------------------|--|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                   | 3 1/4                                  | 4 1/4 | 5 1/4 | 6 1/4 | 7 1/4 | 8 1/4 | 9 1/4 | 10 1/4 | 11 1/4 | 12 1/4 | 13 1/4 | 14 1/4 | 15 1/4 | 16 1/4 | 17 1/4 | 18 1/4 |
| Bloomingtondale   |  |       |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| Area in sq. ft.   | ...                                    | ...   | ...   | ...   | ...   | 81.3  | 95.0  | 118.6  | 133.5  | ...    | ...    | 196.4  | 138.2  | ...    | ...    | ...    |
| No. trees sampled | 0                                      | 0     | 0     | 0     | 0     | 2     | 3     | 3      | 1      | 0      | 0      | 1      | 1      | ...    | ...    | ...    |
| Hampton           |  |       |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| Area in sq. ft.   | ...                                    | ...   | ...   | 49.9  | 57.8  | 81.0  | 102.1 | 120.2  | ...    | 183.6  | ...    | ...    | ...    | ...    | ...    | ...    |
| No. trees sampled | 0                                      | 0     | 0     | 3     | 2     | 1     | 4     | 1      | 0      | 4      | 0      | 0      | 0      | ...    | ...    | ...    |
| North Plainfield  |  |       |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| Area in sq. ft.   | 22.0                                   | ...   | ...   | 42.4  | 67.0  | 71.5  | ...   | ...    | ...    | 152.4  | ...    | ...    | 262.3  | ...    | ...    | ...    |
| No. trees sampled | 1                                      | 1     | 0     | 1     | 3     | 1     | ...   | ...    | ...    | 2      | ...    | ...    | 1      | 0      | 0      | ...    |
| Ringwood          |  |       |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| Area in sq. ft.   | 17.4                                   | 31.3  | ...   | ...   | ...   | 75.4  | 94.9  | 147.8  | 113.0  | ...    | ...    | ...    | ...    | ...    | ...    | ...    |
| No. trees sampled | 3                                      | 1     | ...   | ...   | 0     | 2     | 3     | 6      | 1      | 0      | 0      | ...    | ...    | ...    | ...    | ...    |
| Wayne             |  |       |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| Area in sq. ft.   | 15.0                                   | 15.8  | 27.3  | 35.4  | 58.3  | 72.1  | 92.9  | 145.6  | 124.6  | 175.0  | 382.3  | 254.9  | 286.0  | 358.2  | 442.7  | ...    |
| No. trees sampled | 12                                     | 17    | 15    | 23    | 20    | 11    | 16    | 4      | 8      | 8      | 1      | 2      | 6      | 7      | 4      | 0      |
| West Milford      |  |       |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| Area in sq. ft.   | ...                                    | ...   | ...   | ...   | ...   | 76.2  | 93.7  | 134.8  | ...    | 181.9  | ...    | 183.0  | ...    | 281.2  | ...    | ...    |
| No. trees sampled | 0                                      | 0     | 0     | 0     | 0     | 1     | 3     | 3      | ...    | 2      | ...    | 1      | ...    | 1      | ...    | ...    |

566.2

490.8

604.6

...

0

1

1

1

1

1

1

1

1

1

1

1

Milford townships, large and small trees tended to have the same amount of surface areas at one location as at another.

Statistical significances, shown by computations after conversions to logarithms, indicated that the  $t$  values of the regression coefficients are highly significant for all six locations; that they are all something other than zero. Much confidence is placed in the regression lines by these significances and also by the closeness with which they tend to correspond with one another in fig. 2. Additional interpretations are (1) that regression lines representing locations are nearly alike, as from a homogeneous population, (2) that the average regression is the best available estimate of the population regression by regarding individual regressions as items in a large sample, (3) the regression formula is as follows:

expected logarithm of surface area =  $2.0747 (\log x) - 0.0160$ ,  
and (4) the coefficient of correlations,  $r = 0.9808$ .

The amount of estimated bark areas, by employment of the above logarithmic formula followed by conversion of the logarithms to numbers is presented in table 4.

TABLE 4.—Expected numbers of square feet of bark areas of trees.

|                          |        |        |        |        |        |        |        |        |        |        |        |
|--------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Tree d.b.h., inches..... | 3 1/4  | 4 1/4  | 5 1/4  | 6 1/4  | 7 1/4  | 8 1/4  | 9 1/4  | 10 1/4 | 11 1/4 | 12 1/4 | 13 1/4 |
| Area, sq. ft. ....       | 11     | 19     | 30     | 43     | 59     | 77     | 97     | 121    | 146    | 174    | 205    |
| Tree d.b.h., inches..... | 14 1/4 | 15 1/4 | 16 1/4 | 17 1/4 | 18 1/4 | 19 1/4 | 20 1/4 | 21 1/4 |        |        |        |
| Area, sq. ft. ....       | 239    | 275    | 314    | 355    | 398    | 444    | 495    | 547    |        |        |        |

#### Numbers of Twig Crotches in Elm Trees

Wounds in elm crotches made by the smaller European elm bark beetle, *Scolytus multistriatus* Marsham, which are generally believed to be frequent inoculation courts of the Dutch elm disease organism, *Ceratostomella ulmi* Buisman, suggested that the number or amount of possible inoculation courts might have some relationship with disease infections. The total number of twig crotches in trees, their position in the trees, and other factors might

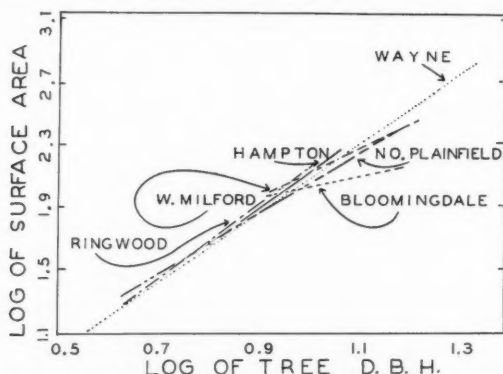


Fig. 2. Regression of surface areas of elm trees on diameters.



TABLE 5.—Average number of twig crotches in small elm trees.  
Basal diameter of elm tree examined, inches

| Group | 1 1/4                      | 1 1/2 | 1 3/4 | 2   | 2 1/4 | 2 1/2 | 2 3/4 | 3   | 3 1/4 | 3 1/2 | 3 3/4 | 4   |
|-------|----------------------------|-------|-------|-----|-------|-------|-------|-----|-------|-------|-------|-----|
| A     | Ave. no. crotches..... 205 | 347   | 417   | 496 | 532   | 694   | ...   | 749 | 1,319 | ...   | ...   | ... |
|       | No. trees examined..... 14 | 13    | 9     | 11  | 4     | 1     | 0     | 1   | 1     | 0     | 0     | 0   |
| B     | Ave. no. crotches..... 216 | 204   | 232   | 261 | 434   | 339   | 512   | ... | ...   | ...   | ...   | ... |
|       | No. trees examined..... 3  | 6     | 7     | 10  | 2     | 1     | 2     | 0   | 0     | 0     | 0     | 0   |
| C     | Ave. no. crotches..... 263 | 306   | 325   | 487 | 528   | 671   | 847   | 835 | ...   | 1,377 | 1,115 | 844 |
|       | No. trees examined..... 3  | 3     | 1     | 7   | 4     | 8     | 3     | 7   | 0     | 2     | 1     | 1   |
| D     | Ave. no. crotches..... 139 | 308   | 204   | 386 | 431   | 345   | 830   | 744 | ...   | ...   | ...   | ... |
|       | No. trees examined..... 1  | 5     | 2     | 3   | 4     | 1     | 2     | 1   | 0     | 0     | 0     | 0   |
| E     | Ave. no. crotches..... 141 | 331   | 372   | 273 | ...   | 787   | 920   | ... | ...   | ...   | ...   | ... |
|       | No. trees examined..... 3  | 5     | 7     | 1   | 0     | 1     | 1     | ... | 0     | 0     | 0     | 0   |
| F     | Ave. no. crotches..... 243 | 208   | 216   | 375 | 388   | ...   | ...   | 740 | ...   | ...   | ...   | ... |
|       | No. trees examined..... 0  | 3     | 3     | 5   | 3     | 2     | 0     | 1   | 0     | 0     | 0     | 0   |

receive consideration in connection with infected trees. Larger trees, which have larger bark areas and also more twig crotches, offer larger targets for attacking beetles regardless of whether or not twig crotches or bark areas are the more frequent inoculation courts of disease organisms. It is not unexpected, therefore, that larger trees, because they are larger targets, might become more frequently diseased than smaller trees. White pine blister rust infections, according to Snell (1928), were more frequent in larger than in smaller trees. Rex and May (1943) have indicated that more of the larger trees had Dutch elm disease symptoms, and unpublished data in the files of the Federal Bureau of Entomology and Plant Quarantine are evidence to support the belief that more frequent disease infections occur in larger than in smaller trees.

The data presented on the number of twig crotches are given under the following subjects: (1) Smaller trees, (2) large branches, (3) number of large branches in larger trees, and (4) estimates of twig crotches in larger trees. The task required for taking census of twig crotches in smaller trees was within the limits of practicability, and the results indicated what might be expected from larger trees where only sampling procedures were practicable.

*Smaller trees.*—Representatives of small trees ( $1\frac{1}{2}$  to  $3\frac{3}{4}$  inches basal diameter) from six groups, uninfluenced by shade from larger trees were taken as samples. All crotches considered subject to attack by the smaller European elm bark beetle, described by Wolfenbarger and Buchanan (1939) were counted. The average number of crotches per tree, according to tree size, and the number of trees examined to obtain the average for each of the six groups are shown in table 5.

Rather marked increases in number of twig crotches with tree size increase is noted in table 5. Each succeeding larger size is usually seen to have more crotches, as might be expected. The present objective is to indicate an estimate of the rate of increase that may be expected. Graphic studies of these data indicated, as did cubic volume contents and square area surfaces, straight line relationships by logarithmic conversions.

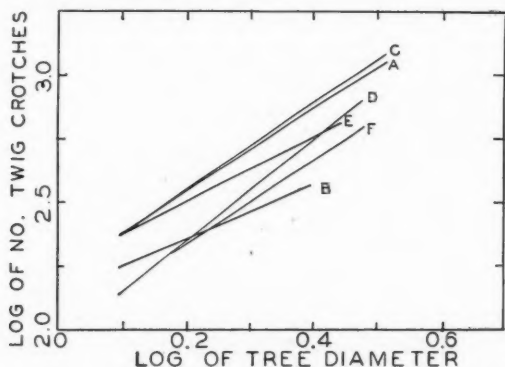


Fig. 3. Regression of number of crotches on basal diameter of elm trees.

Statistical analyses showed that the averages of twig crotches differed significantly according to location. Growth situations and locations are considered, therefore, to have affected the number of crotches in trees, unlike the data relating to cubic volume and bark surface areas. By transformations of the tree diameters and the average numbers of crotches on each, in table 5, estimated numbers of twig crotches, or smoothed regression lines, were calculated from the formulae and are given in fig. 3.

Most of the regression lines have somewhat similar rates of inclination. This indicates somewhat similar rates of increase in the number of twig crotches with increases in tree diameters, regardless of growth location. Differences in position, distances from one another, however, are rather wide, for example between A and B. A generalized formula is not considered applicable, therefore, for estimating the number of twig crotches as it was for tree volumes and surface areas. All regression lines in fig. 3 were statistically significant as something other than zero, except B and E locations whose "t" values were just short of significance. The parallelism of the several regression lines, however, increases the trustworthiness of the ensemble to show the rates of increase.

*Tree branches.*—Samples of tree branches, in several locations, were observed for number of twig crotches. These data show how twig crotches compare with those in trees by reexamining table 5 and fig. 3. Care was exercised in securing sample branches to represent different parts of trees. Early observations indicated that top branches, those exposed to more light, contained more twig crotches than bottom branches, those in shaded situations. Averages of sample tree branches observed are given in table 6, listed according to tree location and basal diameter of tree branch.

TABLE 6.—Average number of twig crotches observed in elm tree branches.

| Township of Tree Growth |   |                       |     | Basal diameter of branches, inches |       |       |       |       |       |
|-------------------------|---|-----------------------|-----|------------------------------------|-------|-------|-------|-------|-------|
|                         |   |                       |     | 1                                  | 1 1/4 | 1 1/2 | 1 3/4 | 2     | 2 1/4 |
| Bedminster              | A | Ave. no. crotches     | 201 | 235                                | 365   | 463   | 553   | ....  | ....  |
|                         |   | No. branches examined | 6   | 6                                  | 4     | 4     | 4     | 4     | 0     |
| Boonton                 | B | Ave. no. crotches     | 141 | ....                               | 261   | 519   | 564   | 648   | ....  |
|                         |   | No. branches examined | 3   | 0                                  | 3     | 1     | 1     | 2     | 2     |
| Chatham                 | C | Ave. no. crotches     | 177 | 369                                | 394   | 344   | 789   | ....  | ....  |
|                         |   | No. branches examined | 7   | 3                                  | 5     | 5     | 2     | 0     | 0     |
| Griggstown              | E | Ave. no. crotches     | 107 | 176                                | 215   | 391   | 385   | 297   | ....  |
|                         |   | No. branches examined | 6   | 8                                  | 3     | 5     | 7     | 1     | 1     |
| Wayne                   | G | Ave. no. crotches     | 265 | 405                                | 630   | 527   | 934   | 1,153 | ....  |
|                         |   | No. branches examined | 9   | 11                                 | 8     | 7     | 11    | 9     | 9     |
| Weston (Conn.)          | D | Ave. no. crotches     | 120 | 151                                | 234   | 340   | 370   | 374   | ....  |
|                         |   | No. branches examined | 15  | 9                                  | 27    | 33    | 57    | 25    | 25    |
| Whippany                | F | Ave. no. crotches     | 149 | 180                                | 250   | 286   | 404   | 465   | ....  |
|                         |   | No. branches examined | 10  | 23                                 | 16    | 15    | 8     | 5     | 5     |
| Zion                    | H | Ave. no. crotches     | 205 | 299                                | 372   | 484   | 843   | ....  | ....  |
|                         |   | No. branches examined | 19  | 10                                 | 7     | 8     | 7     | 0     | 0     |

Increasing numbers of twig crotches are seen with increasing branch size. Statistical analyses showed that locations and diameters both contributed significant differences. The rates of increase for each location are shown by regression lines in fig. 4.

Twig crotches increased in number with branch diameter by straight line relationships through logarithmic conversions (fig. 4). Lack of tendencies for superimposition of the various regression lines and the significant differences found between locations show that the numbers of twig crotches in tree branches vary according to location. Although regression line slopes are similar, the positions are different and must apparently be determined for each location. A generalized formula is not, therefore, expected to give the best estimate of twig crotches on tree branches.

Similar numbers of twig crotches and similar rates of increase are seen for entire trees sampled and for branches sampled (figs. 3 and 4). This suggests that the numbers of twig crotches, although differing by locations, tend to approach an average figure whether the sample source is a branch or a tree.

*Two-Inch Branches in Trees.*—The number of two-inch basal diameter branches in trees of different sizes were counted in two localities, termed swampland and hill slope, and the number of branches counted in miscellaneous places comprises a third group for comparison. Averages of these observations for each group are given in table 7.

These averages, table 7, which exhibit linear relationships by logarithmic conversions, as did the data of averages in other above tables, were used for computing regressions, or expected numbers of branches. The results of plotting regression lines are shown in fig. 5.

The regression lines, although statistically significant as something other than zero, are slightly different from one another in slope and in position. Considerations of the three regression lines are made separately although the differences may have little of practical value for purposes of the estimation. It is suggested, however, that the number of two-inch diameter branches may vary with growth situations, as did the number of twig crotches in trees and branches.

In order to estimate the total number of twig crotches in trees the expected numbers of two-inch branches were multiplied by the number of twig crotches expected in two-inch branches for each group. For each group they were as

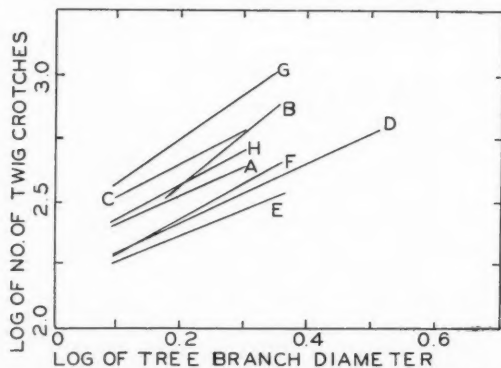


Fig. 4. Regression of number of twig crotches on basal diameters of elm tree branches.

TABLE 7.—Average number of two-inch basal diameter branches observed in elm trees.

|                         | 4 1/4 | 5 1/4 | 6 1/4 | 7 1/4 | 8 1/4 | 9 1/4 | 10 1/4 | 11 1/4 | 12 1/4 | 13 1/4 | 14 1/4 | 15 1/4 | 16 1/4 | 17 1/4 | 18 1/4 | 19 1/4 | 20 1/4 | 21 1/4 |
|-------------------------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Hillslope               |       |       |       |       |       |       |        |        |        |        |        |        |        |        |        |        |        |        |
| Ave. no. branches.....  | 2.0   | 3.3   | 3.4   | 4.1   | 4.5   | 6.5   | 7.1    | 9.1    | 11.3   | 14.0   | 15.0   | 14.9   | 25.8   | 25.0   | 22.0   | 29.0   | 53.0   | ...    |
| No. trees examined..... | 1     | 3     | 7     | 14    | 15    | 15    | 25     | 18     | 18     | 17     | 12     | 7      | 4      | 5      | 1      | 1      | 1      | 0      |
| Swampland               |       |       |       |       |       |       |        |        |        |        |        |        |        |        |        |        |        |        |
| Ave. no. branches.....  | 1.2   | 1.7   | 1.8   | 2.8   | 3.4   | 5.3   | 5.8    | 5.9    | 7.6    | 15.0   | 14.0   | 14.2   | 19.6   | 17.3   | ...    | 25.0   | 21.0   | 35.0   |
| No. trees examined..... | 17    | 16    | 24    | 20    | 10    | 16    | 4      | 7      | 8      | 1      | 2      | 5      | 7      | 4      | 0      | 1      | 1      | 1      |
| Miscellaneous           |       |       |       |       |       |       |        |        |        |        |        |        |        |        |        |        |        |        |
| Ave. no. branches.....  | 1.3   | 2.0   | 2.3   | 3.0   | 2.9   | 4.1   | 6.3    | 5.0    | 10.3   | ...    | 5.5    | 8.0    | 8.0    | ...    | ...    | ...    | ...    | ...    |
| No. trees counted.....  | 4     | 2     | 3     | 3     | 6     | 14    | 14     | 1      | 5      | 0      | 2      | 2      | 1      | 0      | 0      | 0      | 0      | 0      |

TABLE 8.—Estimated number of twig crotches in elm trees.

| Group         | Tree diameter at breast height, inches |       |       |       |       |       |        |        |        |        |        |        |        |        |        |        |        |        |
|---------------|--|-------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|               | 4 1/4                                  | 5 1/4 | 6 1/4 | 7 1/4 | 8 1/4 | 9 1/4 | 10 1/4 | 11 1/4 | 12 1/4 | 13 1/4 | 14 1/4 | 15 1/4 | 16 1/4 | 17 1/4 | 18 1/4 | 19 1/4 | 20 1/4 | 21 1/4 |
| Swampland     | 1,079                                  | 1,619 | 2,291 | 3,076 | 3,975 | 4,988 | 6,133  | 7,383  | 8,727  | 10,175 | 11,718 | 13,459 | 15,258 | 17,160 | 19,148 | 21,334 | 23,568 | 25,915 |
| Hillslope     | 1,493                                  | 2,120 | 2,870 | 3,705 | 4,814 | 5,633 | 6,751  | 8,106  | 9,169  | 10,478 | 11,841 | 13,356 | 14,895 | 16,502 | 18,186 | 19,931 | 21,737 | .....  |
| Miscellaneous | 707                                    | 943   | 1,204 | 1,474 | 1,740 | 2,071 | 2,397  | 2,728  | 3,069  | 3,410  | 3,771  | 4,157  | 4,539  | .....  | .....  | .....  | .....  | .....  |

follows: Swampland trees is 946.5, hill slope trees 765.4, and the miscellaneous group 501.5 crotches. Estimated total numbers of twig crotches in trees are given in table 8.

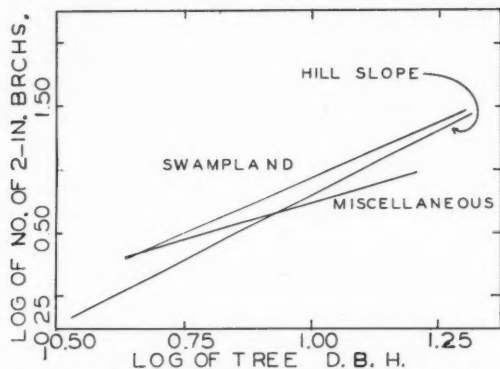


Fig. 5. Regression of number of two-inch branches of elm trees having different diameters.

### Summary

Cubic volume contents and surface areas of the bark of elm trees were found to be quite similar in trees of the same size regardless of the locations in which growth occurred. Volume contents and surface areas were directly related to the diameter of trees at breast height through transformations of the two variables to logarithms. Average rates of increase in volume contents and surface areas of trees, in terms of logarithms, were 2.5699 and 2.0747, respectively, per logarithmic unit increase of tree d.b.h. The numbers of twig crotches in small elm trees were found to vary so widely among locations that no general average provided a satisfactory estimate for all sample sources. In sample branches, of two-inch basal diameter at the base, from large trees the total numbers of crotches were counted, also the number of branches having two-inch basal diameters were counted. With these data calculations were made of the number of twig crotches in large trees. Tables giving the number of cubic feet volume contents, square feet of surface areas of trees, and total number of twig crotches were presented.

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## Hardwood-Conifer Forest Contact Zone in Itasca Park, Minnesota

Murray F. Buell and William E. Gordon

In Itasca Park, Minnesota, maple-basswood stands representative of the climax forest to the south and southeast, and spruce-fir stands representative of climax forest to the north and northeast come into direct contact with each other.

Which, if either, of these communities can logically be considered climax in the Park area has not been clearly determined. Lee (1924) noted that hard maple (*Acer saccharum*) is limited to heavier soils and hence, though able to reproduce itself, could not become the climax. Of the spruce-fir (*Picea-Abies*) type he wrote: "... it seems both possible and probable that it may develop into the true climax of the region." Kell (1938) supported the polyclimax view stating that there are three climax communities: these are: 1. ash-elm-fir on peat, 2. sugar maple-basswood on fine-textured mineral soils, and 3. spruce-fir-birch on coarse-textured mineral soils. Pertinent to consideration here also is the fir-basswood climax of Grant (1934), 80 miles east in Itasca County and much farther within the realm of the northern conifer climax.

The problem is complicated first of all by the complex of non-climatic factors involved. Sharp, glacial-induced variations in physiography and soil prevail almost everywhere. Disturbing factors, first of fire and later of overgrazing by deer, have left an obvious mark on almost all the plant communities. These factors combine to produce very few areas with a degree of maturity and stability sufficient to warrant climax designation.

Superimposed upon this complex of non-climatic factors is the factor of climate itself which complicates the determination and particularly the interpretation of the climax. It seems probable that both forest communities are approaching their climatic limits. By the law of limiting factors, therefore, both communities would hence be more responsive to small changes in climate than would be the case deeper within their respective climatic regimes. As a consequence, the history of the communities can be expected to reflect even the small climatic fluctuations of recent time, some of which may have been sufficient to change the successional trend favoring first one community and then the other. The relative immaturity of the area and the responsiveness of the communities to climatic factors together render the usual developmental approach of limited use in determining the climax and may account in part for the variance in conclusions among those who have studied the problem.

In the final analysis, the answer to the question of which may be considered climax under the present climatic regime lies not so much in the distribution as in the relative competitive ability of the two communities. Specifically, can one reproduce itself and invade the other under conditions of soil and physiography sufficiently stable to warrant climax designation? With this ques-

tion answered, a further comparison with the present distribution may indicate the recent trend in climatic change of which the forests of this area should be good indicators.

### Methods and Observations

Two types of contact zones were studied, the first located along the front of a massed stand of spruce-fir and the second situated on the periphery of a "fir island" wholly within a hardwood stand. Across both contact zones there was a complete transition from the comparatively dense ground cover of the maple-basswood forest to the scant ground cover of the spruce-fir.

*The water factor.*—To study the relationship of the water factor to the transition of ground cover (including maple seedlings), small treeless plots were trenched and refilled to a depth of 2-1/2 feet to remove all tree root competition within the plots. Two of these were two meters square and located in the fir forest, one about three meters back from the edge and the second one about eight meters back. The third was an elongated plot one meter wide by five long, across a section of the contact zone embracing a complete transition in ground cover.

Soil moisture determinations were made over a two-month period in the 1939 and 1940 growing seasons, both for the trench plots and for adjacent undisturbed areas. The 1939 samples were taken at the twelve (12) inch depth, and the 1940 samples from the six (6) and twenty-four (24) inch levels. Average and ranges of soil moisture encountered are summarized in Table 1, the amount of soil moisture being expressed as per cent dry weight.

The data indicate that the soil in the undisturbed spruce-fir stands is drier than that in the maple-basswood, both on the average and during the driest season. The small difference in average percent amounted to approximately 1-1/3 quarts of water per cubic foot of soil as determined by volume-weight measurements made in 1940.

Soil moisture in the trenched plots was in general higher than that in the undisturbed plots (lower panel, Table 1). Of particular significance was the increase in the average and minimum soil moisture in the spruce-fir stand to a

TABLE 1.

| Average Soil Moisture<br>in Percent Dry Weight;<br>Undisturbed forest: | 1939            | 1940           |                  |
|--|-----------------|----------------|------------------|
|  | 12 inches       | 6 inches       | 24 inches        |
| Maple-Basswood   | 5.9 (2.7-8.3)   | 7.9 (4.5-13.1) | 12.4 (10.0-16.3) |
| Spruce-Fir   | 4.7 (2.4-7.4)   | 6.1 (3.1-14.1) | 7.3 (3.1-16.6)   |
| Difference   | 1.2             | 1.8            | 5.1              |
| <hr/>  |                 |                |                  |
| Average Soil Moisture<br>in Percent Dry Weight<br>After Trenching:     |                 |                |                  |
|  |                 |                |                  |
| Maple-Basswood   | 10.2 (7.7-13.4) | 9.1 (4.0-15.1) | 9.7 (6.6-12.4)   |
| Spruce-Fir   | 7.9 (4.1-13.5)  | 9.2 (6.9-13.7) | 7.5 (3.9-15.0)   |

level above that in the undisturbed maple-basswood with its well developed ground cover and reproduction.

In spite of this substantial increase in soil moisture, there was no evidence of maple-basswood reproduction and ground cover advancing onto the trench plots in the spruce-fir forest or moving toward the spruce-fir end of the elongated plot across the contact zone. Growth of ground cover and maple reproduction already established in the maple-basswood end of the elongated plot greatly outdistanced that in surrounding undisturbed areas. Specific measurements on terminal growth of fir and maple seedlings, and on the wild gooseberry (*Ribes Cynosbati*), a representative maple-basswood undershrub, are summarized in Table 2 with the number of plants observed in parentheses.

TABLE 2.  
Growth of Terminal Shoot  
Inside Plot      Outside Plot      Difference in  
growth

| Species   | Inside Plot   | Outside Plot  | Difference in growth |
|---|---------------|---------------|----------------------|
| <i>Acer saccharum</i><br>(2-4 yr. seedlings)..... | 3.20 cm. (12) | 2.59 cm. (12) | 23%                  |
| <i>Abies balsamea</i><br>(2-3 yr. seedlings)..... | 1.99 cm. (9)  | 1.17 cm. (12) | 70%                  |
| <i>Ribes Cynosbati</i> .....                      | 46.3 cm. (4)  | 10.4 cm. (12) | 345%                 |

The number of observations does not justify conclusions regarding the limited response of the maple seedlings in comparison to the other species. All three species measured, however, do agree in reflecting an effective increase in soil water as a result of trenching. That this increase was not effective in advancing the maple-basswood ground cover and reproduction into the spruce-fir stand must be attributed to other factors.

*The light factor.*—The difference in light intensity beneath the canopies of the two forests is as apparent to the casual observer as is the difference between density of ground cover. To determine more definitely the relationship between the light factor and amount of ground cover, transects were laid out along which canopy density measurements and plant counts were made across the contact zones. A Weston light meter, mounted to permit standardized readings, was used to determine light intensity. Percent light transmission of the two forest canopies was determined by comparing readings made in the forest area with those taken in an open area immediately before and after the forest readings.

In Figure 1, the average per cent light transmission and plant count of six transects across a narrow part of the contact zone are graphically portrayed. The correlation is very apparent with both light intensity and amount of ground cover increasing steadily away from the spruce-fir side of the contact zone. A somewhat abrupt increase in number of plants after the light penetration exceeds 5 per cent, suggests that the limiting point for the ground cover is near this value.

In Figure 2, portraying a line transect across a somewhat broader part of the contact zone, the positive correlation between amount of ground cover and light penetration is almost as clear. To this comparison has been added an estimate of root density in terms of basal area of all living trees occurring within two meters on either side of the line. (Although basal area is only very

approximately an estimate of root density, it was not felt that this factor could be completely ignored, especially in view of the well-developed sod formed in the spruce-fir stand by the extensive system of fir roots penetrating

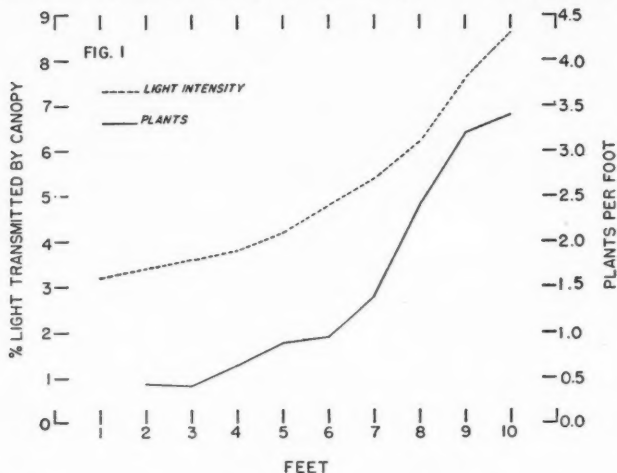


Fig. 1. Correlation between light intensity and ground cover density shown by the average values from six line transects across the contact zone between spruce-fir and maple-basswood.

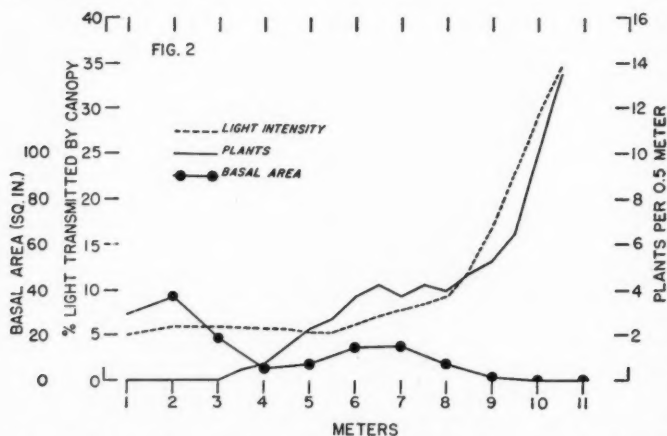


Fig. 2: Correlation between light intensity, ground cover density and basal area of spruce-fir along a line transect across the contact zone between spruce-fir and maple-basswood.

the uppermost levels of moist duff.) The sudden up-turn in amount of ground cover before an appreciable increase in light intensity occurs, coincides with the decrease in estimated root density. The density of tree roots appears, therefore, to retard but not absolutely limit the development of ground cover.

A somewhat longer transect laid out across a spruce-fir "island" in the maple-basswood stand is shown in Figure 3. The correlation between light intensity and ground cover density is largely maintained with little ground cover development below the 5 per cent level of light transmission. The high basal area curve associated with increasing ground cover density beyond the 8-meter point is attributed to a large number of birch trees. While they are properly considered a part of the spruce-fir community ecologically, they never produce the restrictive effect of their coniferous associates on the maple-basswood ground cover, and could perhaps have been considered separately here. Further, although no correction has been applied to the light intensity curve through the birch-dominated part of the transect, there is justification for increasing it beyond the value given by canopy density. This correction

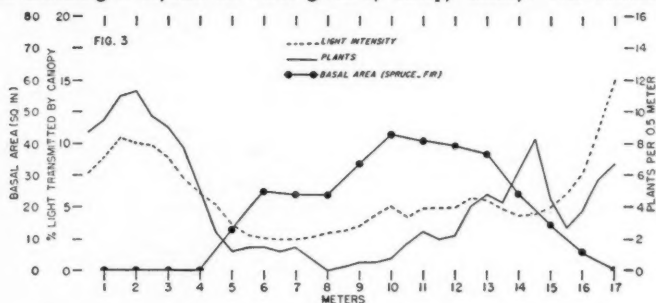


Fig. 3. Correlation between light intensity, ground cover density and basal area of spruce-fir across a spruce-fir island in a maple-basswood stand.

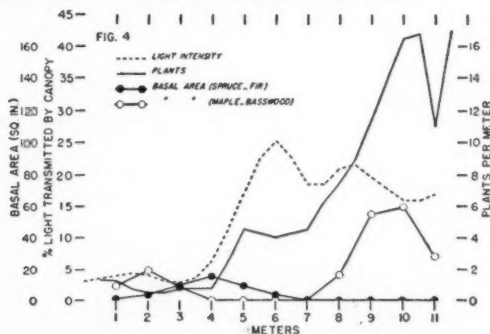


Fig. 4. Correlation between light intensity, ground cover density and the basal areas of spruce-fir and maple-basswood. Transect is across a spruce-fir island in a maple-basswood.

factor for reflection from white trunks amounted to 80 per cent for some aspen stands studied.

A second transect extending across a spruce-fir island and out into the surrounding maple-basswood is shown in Figure 4. Again there is practically no development of ground cover until the forest canopy transmits above 5 per cent of the total light. The retarding effect of root competition is most plainly shown here where the amount of ground cover does not increase with the light curve until the basal area of the spruce and fir reaches nearly zero at the 7-meter point. Beyond this point, light intensity is reduced somewhat by a heavy growth of maple-basswood, but is well above the minimum required by the ground cover as shown by the continued increase in its density.

### Discussion

The results of the present study indicate that water as a factor merely retards the advance of maple-basswood ground cover and reproduction into the spruce-fir stand, while a light intensity of less than 5 per cent absolutely prevents it.

It is not believed that the lower average and minimum soil moisture of the spruce-fir stands is sufficient to completely suppress the maple-basswood ground cover and reproduction in the space of a few meters across the contact zone. This conclusion is supported by the fact that in none of the three seasons of observation, was there any advance of the maple-basswood ground cover toward the spruce-fir in response to appreciably higher soil moisture level in the trench plots. Neither was the ground cover seen to retreat from the spruce-fir side of the contact zone through drying up of the front line plants during the periods of minimum moisture.

The consistent positive correlation between amount of ground cover and the per cent of light transmitted by the canopy is impelling evidence that light is the factor limiting advance of the maple-basswood community into the spruce-fir. As the several transect studies agree in showing, a spruce-fir canopy transmitting less than 5 per cent of total light completely suppresses the maple-basswood ground cover. This suppression is reinforced by, but is not dependent upon, root density of the fir trees.

An appreciable increase in prevailing temperature, acting as a modifying factor for both low light intensity and soil moisture, might substantially change the relative competitive positions of the two communities. However, under the reasonably stable soil and physiographic conditions characterizing the areas under study, the present climate permits the spruce-fir community to retain its position in the areas fully occupied by it. Maple-basswood cannot, therefore, be considered climax in the Itasca Park area.

Evidence for the invasion of maple-basswood by spruce-fir is as yet entirely inconclusive. The narrow contact zone where the trench plots were located shows no evidence of such invasion. The spruce-fir forest stops abruptly and the hardwoods begin. The "fir islands" scattered through the hardwood forest present a less static situation. These "islands" are isolated bits of young fir forest of varying size, usually 15 to 30 meters in diameter. Maple-basswood reproduction and ground cover is excluded from them in the same way as it

is from the continuous spruce-fir forest. Conceivably if additional such "islands" can establish themselves and hold on, it would ultimately result in a conquest by infiltration. But the conditions under which such "islands" become established and how persistent they may be have yet to be determined. Extremely young ones were not found. Some that had become established are dying. The spruce-fir is certainly the more aggressive of the two. However, it remains for further study to reveal the answer to the question: is the spruce-fir community capable of advancing into and superseding the maple-basswood and thus of being considered climax under the present climatic regime?

### Summary

In Itasca Park, Minnesota, maple-basswood stands representative of the climax forest to the south and southeast, and spruce-fir stands representative of the climax forest to the north and northeast come into direct contact with each other. Determination of which of these communities may be considered climax is complicated by the immaturity of the soil and physiography, and by the nearness of the communities to their respective climatic limits.

The problem of determining the climax is approached here on the basis of the relative competitive ability of the two communities under conditions of soil and physiography sufficiently stable to warrant the climax designation.

1. From a study of soil moisture in undisturbed and trenched plots it is concluded that water, while it may have a retarding effect, is not of a primary importance in preventing maple-basswood reproduction and ground cover from invading contiguous spruce-fir forest.

2. Light penetration of less than 5 per cent, characteristic of the fir canopy, absolutely prevents maple-basswood reproduction and ground cover from invading the spruce-fir forest.

3. The dense sod formed by fir roots has a contributing influence in keeping back the hardwood flora.

Complete inability of the hardwood community to invade the conifers indicates that the former cannot be considered climax under the present climatic regime. Some apparent infiltration of the hardwoods by elements of the conifer community suggests that recent climatic fluctuations favor the spruce-fir forest over the maple-basswood.

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## Anther Color in Willows

Ernest C. Smith

The writer's attention was first directed to the color of the anthers during several years of field work in connection with a study of Colorado willows. He observed that the anthers of several species were a bright red, the color varying in intensity in different species and at different degrees of development.

The interest thus aroused led to an examination of the immediately available literature. This indicated that the anther color of willows had received very little attention by American writers. Of 18 manuals and local floras consulted, only two contain even general statements. Rydberg (1914) states "Anthers usually yellow," Small (1933) says, "Anthers yellow or reddish." Gray's Manual (1908) has no general statement, but mentions the red color in two species, *Salix candida* Fluegge and *Salix purpurea* L. By implication this suggests that the red color is exceptional.

Reasons for the omission are not hard to find. Like the scales of the aments, in most species of willow the color of the anthers undergoes a series of changes during the development of the organ, sometimes from a darker to a lighter shade, sometimes from a lighter to a darker one; after dehiscence the free margins roll back so that the original surface is largely concealed, the shed pollen giving a prevailing yellow or tan color to the whole ament. Original descriptions of many species were made by writers who had seen only dried material and that in limited quantity. The brief form of description adopted at an early date omitted characters not considered diagnostic. The number of stamens and the presence or absence of hairs on the bases of the filaments were clearly visible and dependable in herbarium specimens while anther color was variable and sometimes obscure.

A further search, however, showed that the character had early been recognized as significant and belonging to a complete description. Andersson (1868) not only gave the color of the anthers in freshly gathered material when it was known to him, but also noted the change of color caused by the drying process. His general statement precedes that of Small by three quarters of a century,—"The anthers are typically golden yellow, but in some purple, after anthesis fuscous" ("Typice aurantiacis, in aliis purpureis, post anthesin fuscis"). Apparently he had seen and perhaps grown in the garden, several species of American willows, but of most species he knew only dried plants. The exceptions show his keen observation and interest in the character. He describes *S. glauca* L. as having "anthers at first reddish, finally fuscous" (antheris primo rufescentibus, demum fuscis"); *S. tristis* as having "anthers in the beginning red, later yellow" ("antheris initio rubicundis, demum flavis"). He confesses ignorance of the original color in most American species, but frequently mentions the fact

that the anthers in drying had changed to a darker color ("Antheras nigricantes").

Schneider, in the latest monographic treatment of American willows (1922), has called attention to the possible usefulness of anther color in diagnosis. In several sections of his artificial key to the staminate forms he so uses it in a very effective manner. Apparently in a few cases he was familiar with fresh material, in others he knew only the color in the dried specimens and used that in his key. He lists as having violaceous anthers *S. reticulata* and *S. argyrocarpa*; as having anthers violaceous or purple, *S. alaxensis*, *S. candida*, *S. arbusculoides*, *S. tristis*; as having yellow anthers, *S. vestita*, *S. Wolfii*, *S. Hartwegii*, *S. mexicana*, *S. irriorata*, *S. Piperi*, *S. monticola*, *S. calcicola*, *S. humilis*, *S. lutea*, *S. lasiolepis*, *S. missouriensis*, *S. adenophylla*, *S. commutata*, *S. amplifolia*, *S. Hookeriana*, *S. pyrifolia*, *S. Barclayi*, *S. glaucophylloides*, *S. petiolaris*. Of the last group he says "Sometimes a little reddish in some part" ("interdum partim paullo rubescentes").

In a footnote he says, "In herbarium specimens it is often difficult to ascertain clearly the color of the anthers, because old anthers of other species usually become blackish in drying. Sometimes the very young anthers may be somewhat purplish, at least at the apex, while later they are normally yellow or golden. Probably the young anthers of *S. argyrocarpa*, *S. humilis*, *S. pedicellaris*, and the rare *S. delnortensis* are more or less purpurascens too."

While anther color as a key character in herbarium specimens is thus usable only by experts, the inclusion in descriptions of the color of well developed, but unopened anthers is very desirable for collectors and others who deal with fresh material. As separate artificial keys for staminate and pistillate plants become more generally available the color thus restricted may become a valuable key character.

With published information of the character at this stage, the writer desires to report his field notes and those communicated to him by Prof. W. C. McCalla of Alberta, Canada, concerning the "alii" of Andersson and the "others" of Schneider, meaning thereby species in which the anther color is "not yellow" or least not always and entirely so.

To make the picture as complete as possible notes of the color of the anthers of dried specimens of these species in the herbarium of the Colorado A. and M. College are included. These specimens were studied under a binocular microscope with a magnifying power of 17. This is important, especially when only a few anthers remain unopened, in which case the general appearance is often misleading. The terms "black" or "blackish" are used to include the dark grayish tint known as "fuscous." The statements contributed by Prof. McCalla are intialled and the localities from which the specimens came are stated.

*Salix anglorum* Cham. var. *kophophylla* Schn. Anthers red. (W. C. M.)  
Alberta.

- Salix Barrattiana* Hook. Anthers rich red on purplish filaments which are fully extended before dehiscence. (W. C. M.) Alberta. Anthers dry almost black. (E. C. S.)
- Salix brachycarpa* Nutt. Anthers of specimens from above timberline dark red, drying almost black. (E. C. S.) Anthers reddish at first, becoming yellowish as the filaments reach their full extension. (W. C. M.) Alberta.
- Salix candida* Fluegge. Anthers dark crimson on mauve filaments (W. C. M.), Drying almost black. (E. C. S.)
- Salix delnortensis* Schn. Anthers first red, then purplish (C. R. Ball.) These dry purplish to almost black; filaments fully extended before dehiscence. (E. C. S.)
- Salix glaucops* Anders. Anthers at first red or orange-red, very showy, turning yellow before dehiscence. (W. C. M.) Anthers dry almost black; filaments fully extended before dehiscence. (E. C. S.)
- Salix MacCalliana* Rowlee. Anthers red at first, becoming yellow before dehiscence. (W. C. M.) Alberta. Dehiscence occurs before the filaments are fully extended, no unopened anthers in dried specimen. (E. C. S.)
- Calix monochroma* Ball. Anthers more or less reddish at first, soon yellow. (W. C. M.), Alberta. These dry dark, but dehiscence occurs before filaments are fully extended and the shed pollen obscures the color. (E. C. S.) California.
- Salix myrtillifolia* Anders. Anthers bright red at first, yellow at time of dehiscence. (W. C. M.) Alberta.
- Salix petrophila* Rydb. Anthers dark red, drying almost black. (E. C. S.) Col.
- Salix planifolia* Pursh. Anthers a rich red, drying almost black; filaments fully extended before dehiscence. (E. C. S.) Col.
- Salix planifolia* var. *Nelsonii* Ball. Anthers bright to fainter red, drying almost black, but very few unopened to show this fact, as dehiscence takes place before filaments are fully extended. (E. C. S.) Col.
- Salix pseudolapponum* Von Seem. Anthers dark to lighter red, drying purplish to violaceous; filaments extended before dehiscence. (E. C. S.) Col.
- Salix subcoerulea* Piper. Anthers brilliant to fainter red, drying almost black; dehiscence occurring before filaments are fully extended. (E. C. S.) Col.
- Salix irrorata* Anders. Anthers usually yellow, but sometimes with brilliant red tips, all becoming yellow before dehiscence; usually the anthers dry a tan color, but when red tips have been present, unopened anthers dry almost black; dehiscence begins, but is not complete until filaments are fully extended. (E. C. S.) Col.
- Salix petiolaris* Smith. Unopened anthers usually yellow, but occasionally with red and yellow anthers present in the same ament, all becoming yellow

before dehiscence, drying tan color usually, but sometimes tinged with red. (E. C. S.) Col.

The correlation between the color of fresh unopened anthers which display some shade of red and the dark color in dried specimens leads one to surmise the same relation in the species where herbarium specimens are in hand, but in which there has been no opportunity to make comparison with freshly gathered material. In order to direct the attention of collectors to species in which the correlation remains to be proved or disproved a list of observations on herbarium specimens is included. *Salix arbusculoides* Anders. Schneider lists this as having anthers violaceous or purplish. A specimen from Alberta, Canada, shows anthers in an early stage of development yellow, those somewhat older gaining a red tint as the filaments elongate, some anthers almost black.

*Salix arctica* Pal. Anthers almost black. Alaska.

*Salix adenophylla* Hook. (*S. syrticola* Fern.) Anthers purplish to fuscous.

*Salix Barclayi* Anders. Alaska material has mature unopened anthers dark gray to almost black, Alberta material more definitely black.

*Salix adenophylla* from Indiana has anthers purplish to darker.

*Salix cordifolia* Pursh. *S. callicarpaea* (Trautv.) (Fern.) Almost black. Hudson Bay.

*Salix discolor eriocephala* (Michx.) Anders. Black. Wis.

*Salix glauca* var. *glabrescens* (Anders.) Schn. Violaceous to black. Sask.

*Salix glaucoptis* Anders. Purplish to black. Banff, Alberta.

*Salix Hookeriana* Barr. Purplish to black. Brit. Col.

*Salix humilis* Marsh. Black. N/C.

*Salix mackenzieana* (Hook.) Barr. Black. Alberta, Ore.

*Salix pulchra* Cham. Black. Alaska.

*Salix pyrifolia* Anders. Black. Sask.

*Salix reticulata* L. Black. Alaska.

*Salix rotundifolia* Trautv. Black. Sask.

*Salix scouleriana* Barr. Black. Ida., Wash.

*Salix sitchensis* Sanson. Black. Wash., Alaska.

*Salix stolonifera* Cov. Black. Alaska.

As a result of these observations in the field and in the herbarium certain tentative conclusions may be drawn.

1. Some shade of red is always present in the mature, but unopened anthers of certain species, at least under the conditions obtaining in the northern part of the Rocky Mountain area, is distinctive and a good supplementary key character for use with freshly gathered material.

2. In a limited number of species the red color undergoes obvious changes during the period of anthesis. Since more than one stage of development of the anthers is usually present, sometimes in the same ament, this change of color may be regarded as diagnostic.

3. In a few species the occurrence of red in the anthers is occasional and sporadic, restricted to a few individuals or to an unusual season.

4. Study of herbarium specimens of species which are known to have red anthers when collected suggests a correlation between a distinctively dark color in the unopened anthers when dried and an original red color in freshly collected specimens.

5. Anther color can be used effectively in the identification of herbarium specimens only after such correlations have been established and when fairly mature unopened anthers are present.

6. Red anthers appear to be more common in the species of high altitudes or high latitudes and more pronounced in specimens exposed to strong direct light. Species with yellow anthers also are found under the same conditions of exposure to light. An internal factor appears to be responsible.

7. The present study covers too limited a field to warrant any statement as to the constancy of the phenomena reported and is submitted in the hope of stimulating observation and eliciting reports from other parts of the United States and Canada.

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## Notes on Cladophora

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### *Cladophora pithophoroides*, sp. nov.

*Plantis viridibus vel pallide viridibus densis caespitosis erectis 5-20 mm. longis, ad saxa et lignum affixis, filamentis praecipuis rigidiusculis, cellulis subclavatis 45-55  $\mu$  crassis diametro 4-8-plo longioribus, ramis oppositis erectis cellulis ramorum ultimorum 30-40  $\mu$  crassis diametro 10-25-plo longioribus, cellulis ad bases rhizoideis, ramis inferne radiciformibus non raris, membranis crassissimis lamellatis striatis.*

Plants dense, light to grass-green tufts, 5-20 mm. long, attached to stones and wood; main filaments rigid, cells subclavate, 45-55  $\mu$  in diameter, 4-8 times as long as broad; branches erect, opposite, cells of the ultimate branches 30-40  $\mu$  in diameter, 10-25 times as long as broad; cells at the base rhizoidal, producing rhizoidal branches; cell-walls thick, lamellate with evident striae. The densely tufted growth habit and intertwined rhizoidal branches appear to ally this species most closely to *Cladophora aegagropila* (L.) Kütz. It differs in the constant presence of thickened cell-walls at the ends of the filaments and, so far as is known, in the lack of a free-floating growth-stage.

LOUISIANA: in tufts on submerged timbers, Bogue Falaya River at Covington, St. Tammany Parish, 24 Aug. 1944, *L. H. Flint*; discoid tufts on cement spillway, University Lake, Baton Rouge, 23 Nov. 1944, *L. H. Flint*. GUATEMALA: Dept. Alta Verapaz: on limestone around waterfall at Sebol, Rio Sebol, 9 May 1942, *J. A. Steyermark*, 46316. Dept. Peten: on limestone rock in sulfur spring, shore of Laguna Petexbatum (Laguna Mexico), south of Sayaxche, 3 May 1942, *J. A. Steyermark*, 46239; on log in sulfur spring, shore of Lake Petexbatum, 3 May 1942, *J. A. Steyermark*, 46236a (TYPE in the Cryptogamic Herbarium, Chicago Natural History Museum).

### *Cladophora pulverulenta* (Mert.) comb. nov.

*Conferva pulverulenta* Mert. in Jürg., *Alg. Aquat.*, Dec. 19, No. 4. 1824.

The specimens in Jürgens' *Algae Aquaticae* in the herbaria of the Chicago Natural History Museum and the Missouri Botanical Garden, on which the name *Conferve pulverulenta* Mert. is based, are typical plants of *Cladophora expansa* of present-day usage. The type of *Cladophora expansa* (Mert.) Kütz. is, on the other hand, a loosely branched specimen of *Cladophora refracta* (Roth) Kütz. according to modern usage.

CHICAGO NATURAL HISTORY MUSEUM,  
CHICAGO, ILL.

## The Amphipod Genus *Unciola* on the East Coast of America<sup>1</sup>

Clarence R. Shoemaker

The genus *Unciola* was established by Thomas Say in 1818 (Jour. Acad. Nat. Sci., Phila., vol. 1, pt. 2, p. 388) upon specimens taken at Egg Harbor, New Jersey. As is so often the case with early descriptions, his specific description is entirely lacking in specific characters and is quite inadequate for fixing his species *irrorata*. In studying the material of this genus in the collection of the United States National Museum, it is evident that several distinct species have been ascribed to the species *irrorata* by different authors. I am here restricting Say's specific name to the most abundant species of the genus, which inhabits the bays and shallow waters of the northeast coast of the United States, and which is the species described and figured by S. J. Holmes in his "Amphipoda of Southern New England."

*Unciola leucopis*, which was described by H. Kroyer from the Arctic and which has been recorded from northern Europe, northern Asia, and Greenland, is now being recorded off Nova Scotia and from the Bay of Fundy. *Unciola laticornis*, described by H. J. Hansen from Davis Strait in 1887 and not recorded elsewhere, is now reported off the east coast of the United States. *Unciola laminosa*, described in 1912 by Dr. A. S. Pearse from a few specimens taken by the *Albatross* in the northeastern part of the Gulf of Mexico, is here recorded from the Caribbean coast of Colombia. Besides these well established species, I am here describing four new species from the east coast of the United States, each of which is represented in the national collections by numerous mature specimens of both sexes.

### UNCIOLA IRRORATA Say

Figs. 1, 2

1818. *Unciola irrorata* Say, Jour. Acad. Nat. Sci., Phila., vol. 1, pt. 2, p. 389.  
1873. *Unciola irrorata* Smith (part). In A. E. Verrill: Report upon the Invertebrate Animals of Vineyard Sound and Adjacent Waters. Rep. Comm. Fish and Fisheries, 1871-1872, pp. 340, 367, pl. 4, fig. 19.  
1905. *Unciola irrorata* Holmes, Bull. Bur. Fish. for 1904, vol. 24, p. 520, text fig.  
1918. *Unciola irrorata* Kunkel (part), Conn. State Geol. and Nat. Hist. Survey, Bull. 26, p. 166, fig. 50.

*Male*.—Body dorsally broad and flattened; first segment longer than the following segments. Head, rostrum rather long and acute, and continued down the front of the head as a keel incised by a prominent sinus; lateral lobes quadrate with upper corner inclined to be somewhat sharply produced or very narrowly rounding, the lower corner more broadly rounding; eye somewhat oval and black. Antenna 1 a little longer than antenna 2, first joint

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stouter than second, bearing on the lower border a distal spine and 2 or 3 spines proximally; second joint about one-fourth longer than the first, and bearing no spines; third joint half the length of the second; flagellum of from 16 to 24 joints; accessory flagellum of 4 or 5 regular joints and a small terminal joint. Antenna 2 strong and robust, first and second joints short; first joint produced forward below into a flat horizontal rounding lobe; second

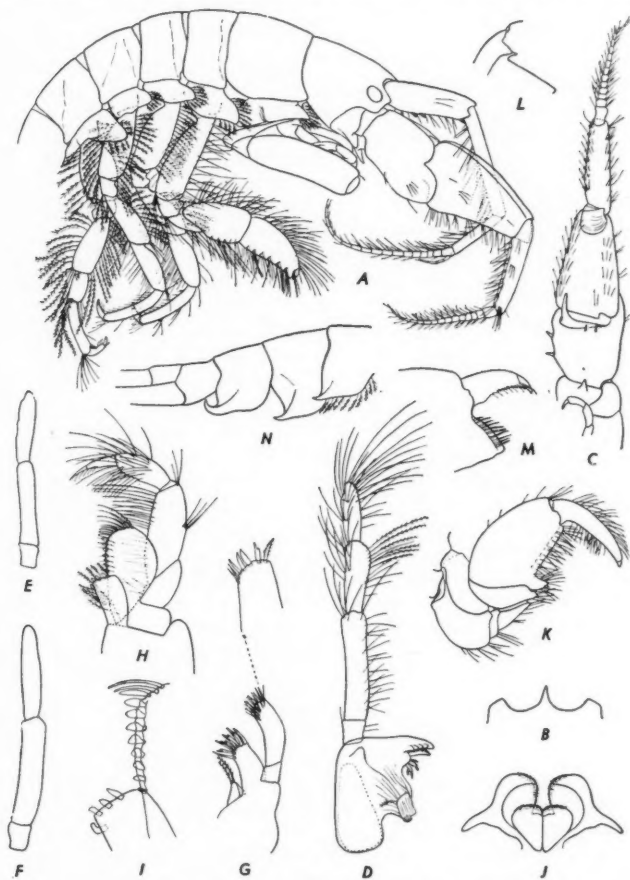


Fig. 1. *Unciola irrorata* Say. Male. a, anterior half of animal; b, rostrum; c, left antenna 2, ventral side; d, left mandible with abnormal four-jointed palp; e, f, mandibular palps of two other males; g, maxilla 1; h, maxilliped; i, teeth of maxilliped; j, lower lip; k, gnathopod 1, outer view; l, gnathopod 1, inner view; m, palm and seventh joint of gnathopod 2; n, metasome segments.

joint bearing a prominent gland-cone; third joint bearing 2 spines on inside surface, sometimes 1 or 2 small spines on ventral distal edge and a large slightly curved movable distal spine between the third and fourth joints; fourth joint with the lower inside edge bearing shallow serrations with a small spine at the base of each depression, inside surface of joint bearing a longitudinal row of short spines and produced forward into a short triangular lobe; fifth joint slightly serrate on the lower inside edge with a short spine at the base of each depression; flagellum of 15 to 18 joints.

Mandible, molar prominent and strong with a rounding knob at base near the insertion of the palp; spine-row of 2 or 3 spines and a few plumose setae; palp with third joint shorter than second. The palp of the left mandible of the specimen figured has 4 joints as I have figured, but the palp of the right mandible contains the 3 normal joints. Maxilla 1, inner plate short and conical and bearing 2 apical plumose setae; outer plate with 9 spine-teeth; palp rather long, second joint armed distally with 5 spine-teeth and 2 slender spines below which is an oblique row of about 7 slender spines. Maxilla 2 much as figured by Sars for *U. leucopis* (1894, Crust. Norway, pl. 222, M2). Maxilliped, inner plate armed distally with 3 teeth, and on the inner border near the extremity with a hook-like spine; outer plate armed on inner margin with about 9 teeth; palp with fourth joint long and bearing a long slender nail. Lower lip with inner lobes very prominent, and mandibular processes long and narrow.

Gnathopod 1 stout and strong; fifth joint rather narrow with lower margin produced into a small jagged lobe which projects downward nearly as far as the lobe of sixth joint; sixth joint about three-fourths as wide as long, outer margin strongly convex and bearing a few short spinules or setae, palm straight, crenulate and produced forward into a short tooth, hind margin of joint forming a defining lobe surmounted by a very small spine; seventh joint slightly curved with tip closing against the defining lobe, inside surface bearing several groups of forward-curving setae, and lower margin without serrations, or if any extremely small. Gnathopod 2 much slenderer than 1, fifth joint wider but equal in length to sixth; sixth joint tapering distally and curving slightly downward, palm slightly chelate, very finely serrulate, somewhat convex, and bearing on the inner side a submarginal row of 9 or 10 slender spinules; seventh joint fitting palm and armed on lower concave margin with a row of sharp forward-pointing teeth and a row of setae.

Peraeopods 1 and 2 alike, second joint very moderately expanded with plumose setae on front and hind margin; fourth joint slightly expanded with plumose setae on front margin only; seventh joint with a row of curved setae on inner margin. Peraeopod 3 shorter than 2, second and fourth joints slightly expanded and bearing plumose setae on front and hind margin; fifth joint bearing 2 short curved spines near upper end and 2 at the lower margin. Peraeopods 3, 4, and 5 increasing consecutively in length. Peraeopods 4 and 5 much alike, second joint slightly expanded and bearing plumose setae on front and hind margin; fifth joint bearing a short spine near the upper end; seventh joint with a row of curved setae on inner margin. Coxal-plate 1

produced downward anteriorly rather acutely; coxal-plates 2, 3, and 4 not produced acutely downward, but with front margins more or less rounding; coxal-plate 5 with front margin produced downward into a triangular lobe, and hind margin produced slightly backward into a narrow rounding lobe; coxal-plates 6 and 7 produced backward into a narrow rounding lobe which extends little beyond the lower hind corner of the body segment. The coxal-plates and the pereopods are bordered with plumose setae.

Metasome segments 1 and 2 with lower margin produced backward into a sharp angle; segment 3 produced backward into a strong upward-curving process. There is considerable variation in these segments, the posterolateral processes being much less upcurved in some specimens than in others. Uropods 1, 2, and 3 are as shown by my figures. Peduncle of uropod 1 produced distally below into a conspicuous, triangular lobe. Uropod 3 extends beyond

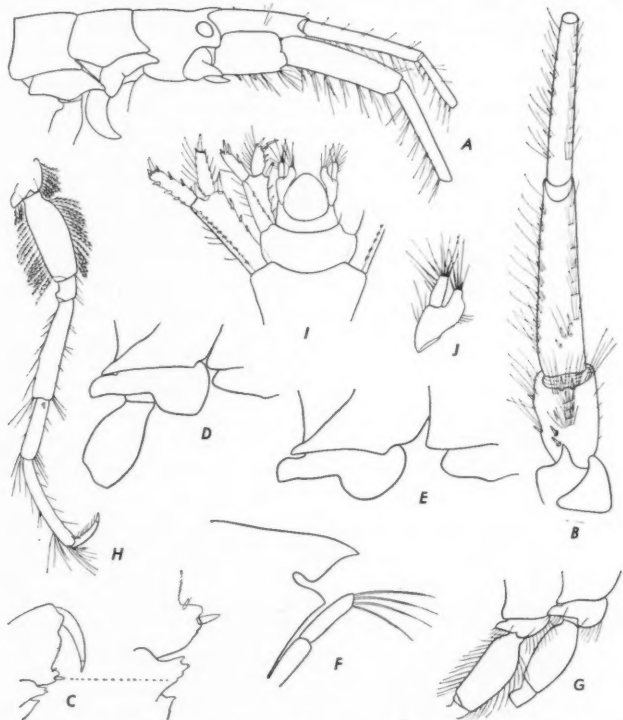


Fig. 2. *Unciola irrorata* Say. Female. a, anterior part of animal; b, left antenna 2, ventral side; c, gnathopod 1; d, fifth coxal-plate; e, fifth coxal-plate of a very large female. Male. f, rostrum; g, coxal-plates 6 and 7; h, pereopod 5; i, urosome and appendages; j, uropod 3.

telson, the peduncular lobe does not extend beyond the ramus. Telson as broad as long with sides curving toward the evenly rounding apex. Length from rostrum to end of uropods 12 mm.

*Female*.—Head, rostrum as in male; lateral lobes not square as in the male, but rounding in front, with upper corner scarcely perceptible. Antenna 1 much as in male, first peduncular joint bearing on lower margin 1 distal spine and 2 or 3 proximal spines; flagellum consisting of from 18 to 25 joints; accessory flagellum of 4 or 5 regular joints and a very short terminal joint. Antenna 2 not nearly so stout as in male; first and second joints nearly as in male; third joint with 2 or 3 small spines on ventral surface, 1 to 4 somewhat larger spines on inside surface, and 2 spines at medium distal ventral margin; fourth joint with 2 to 4 spines near the proximal end of the ventral surface, and inside lower margin bearing a row of about 10 spines above which on the inside surface of joint is a longitudinal row of 5 to 8 spines; fifth joint bearing on the inside edge a row of about 6 spines; flagellum of 10 to 18 joints.

Gnathopod 1 not quite as stout as in male; the palm of sixth joint not bearing a distal tooth but instead a slight protuberance. Coxal-plate 1 much like that of male. Coxal-plate 2 with front margin produced into a downward-pointing narrow lobe. Coxal-plate 3 produced in front to a rather sharp angle. Coxal-plate 4 rather narrowly rounding in front. Coxal-plate 5, front lobe more quadrate than triangular, but in the oldest or largest females it is evenly rounding as shown by my figure. Length from rostrum to end of uropods 12 mm.

The type of *Unciola irrorata* was deposited by Say in the Academy of Natural Sciences at Philadelphia and was lost when their collections were destroyed by fire. I am therefore designating a male specimen, taken in 21 fathoms at Hen and Chicken Shoal, off Rehoboth, Delaware, by Horace G. Richards, as neotype, U. S. National Museum No. 80488.

In the National Museum collection there are specimens of *U. irrorata* from St. Pierre Harbor, Newfoundland and from off the southern coast of South Carolina. Between these extremes there are many records, chiefly from New England waters. It occurs from low tide down to 155 fathoms.

*Unciola irrorata* has been mentioned frequently in literature, but in the great majority of cases it is impossible to tell what species has actually been referred to. H. J. Hansen<sup>2</sup> records and figures this species from West Greenland, but, as A. E. Ortmann<sup>3</sup> has stated, it was not *U. irrorata* but *U. leucopis* (Kröyer) that he recorded. A. S. Packard<sup>4</sup> recorded *U. irrorata* from Caribou Island, Southern Labrador in 1863, but according to Ortmann<sup>2</sup> Sars believed it to be another species, perhaps *U. leucopis*.

<sup>2</sup> Vidensk. Meddel. fra den Naturh. Foren. i Kjobh., ser. 4, vol. 9, p. 164, pl. 6, fig. 5-5a, 1887.

<sup>3</sup> Proc. Acad. Nat. Sci., Philadelphia, p. 154, 1901.

<sup>4</sup> Canadian Naturalist and Geologist, p. 19, 1863.

## UNCIOLA LEUCOPIS (Kröyer)

Fig. 3

1845. *Glaucome leucopis* Kröyer, Naturh. Tidsskr., ser. 2, vol. 1, p. 491, pl. 7, fig. 2a-e.  
 1894. *Unciola leucopis* G. O. Sars, Crust. Norway, vol. 1, p. 620, pl. 222.  
 1901. *Unciola leucopis* Ortmann, Proc. Acad. Nat. Sci., Phila., 1901, p. 154.  
 1935. *Unciola leucopis* Schellenberg, Skrifter om Svalbard og Ishavit, Oslo, No. 66, p. 29.  
 1935. *Unciola leucopis* Chevreux, Camp. Sci. Monaco, fasc. 90, p. 130.

G. O. Sars has given a good description and figures of this species. I am, however, giving here a few figures, showing some of the characters in detail, taken from specimens from Nova Zembla which were sent to the National Museum by Dr. Eupraxie Gurjanova of the Zoological Institute, Academy of Sciences, Leningrad. The second antenna of the male is only moderately developed, and the third peduncular joint does not have the movable spine at the distal ventral margin, but in its place there is a low

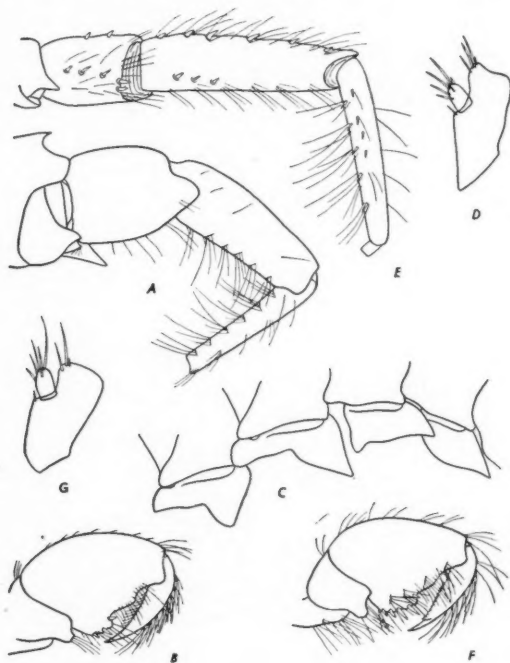


Fig. 3. *Unciola leucopis* (Kröyer). Male. a, antenna 2; b, gnathopod 1; c, coxal-plates 3 to 6; d, uropod 3. Female. e, left antenna 2, ventral side; f, gnathopod 1; g, uropod 3.

inconspicuous tubercle. The specimens from Nova Zembla measure about 15 mm. in length; those from Nova Scotia are smaller.

*U. leucopsis* is represented in the National Museum collection by specimens taken east of Nova Scotia; Bay of Fundy; off Thatcher's Island and off Cape Cod, Massachusetts; and Georges Bank (east of Massachusetts). It was taken by the scientific expeditions of the Prince of Monaco in 1887 at station 161, 46° 04' N., 49° 02' W., at a depth of 692 fathoms, which appears to be the greatest depth at which the species has been recorded. *U. leucopsis* is an arctic and boreal species, and Georges Bank appears to be the most southern record. Ortmann and Hansen have recorded it from West Greenland (Hansen under the name *U. irrorata* Say). In 1935 Dr. A. Schellenberg recorded it from East Greenland.

#### UNCIOLA LATICORNIS Hansen

Fig. 4

1887. *Unciola laticornis* Hansen, Vidensk. Meddel. fra den naturh. Foren. i Kjøbh., ser. 4, vol. 9, p. 166, pl. 6, figs. 7-7b.

This species was described by Hansen from the west coast of Greenland in 1887 and has not been recorded since. I find, however, that this species is well distributed on the northeast coast of the United States. I am giving some figures of appendages not shown by Hansen and am also giving a short description of the animal. The female has not heretofore been described. A. Della Valle, in the Gammaridea of the Gulf of Naples (Fauna und Flora des Golfes von Neapel, Monogr. 20, 1893, p. 338) made *U. laticornis* a synonym of *U. irrorata*, but these two species are quite distinct.

*Male*.—Head, rostrum rather prominent and constructed about as in *U. irrorata*; lateral lobes nearly quadrate, with upper corner sharply angular and lower corner narrowly rounding. Eye not discernible, the specimens having been in alcohol for a long time. Antenna 1 long and slender; first joint about two-thirds the length of second, armed below with 2 distal spines followed by 3 nearly evenly placed spines; second joint long and slender; third joint about one-fourth the length of the second; flagellum longer than the peduncle and composed of from 24 to 27 joints; accessory flagellum of from 2 to 4 regular joints and a very small terminal joint. Antenna 2 very strongly developed, as shown in my figure; second joint with very long gland-cone and a prominent distal tooth on the inner margin of joint; third joint armed on the ventral surface with 3 or 4 long distal spines, and a single spine on the inner margin; fourth joint armed on the ventral surface with 3 or 4 prominent spines near the proximal border and 2 rows of spines on inner margin; fifth joint with a row of spines on inner margin; flagellum composed of about 14 joints. Mouth-parts not differing materially from those of *U. irrorata*.

Gnathopod 1, palm with a rather low distal protuberance, and the defining lobe does not bear a spine; seventh joint with very fine forward-pointing teeth and a few setules on inner margin. Gnathopod 2, palm almost

transverse, very finely serrate, and bearing a submarginal spine at the defining angle; seventh joint bearing forward-pointing serrations and a few setae on the inner margin. Peraeopods all slender with very little expansion of the second joint. All of the material examined had been in alcohol a long time and not a single specimen had all of the peraeopods attached. Coxal-plate 1 produced forward into a sharp, narrow point. Coxal-plates 2 to 4 have the lower front angle evenly rounding. Coxal-plates 5 to 7 with front lobe shallow and evenly rounding below, and hind lobe bluntly rounding and extending very little beyond the body segment.

Metasome segments with the lower lateral posterior corner produced directly backward and not at all downward. Uropod 1 with the peduncle produced distally below into a prominent triangular lobe. Uropod 3, peduncle expanded laterally into a conspicuous lobe bearing a spine and two setules. Length from rostrum to the end of the uropods about 11 mm.

*Female*.—The female differs from the male only in antenna 2 and gnatho-

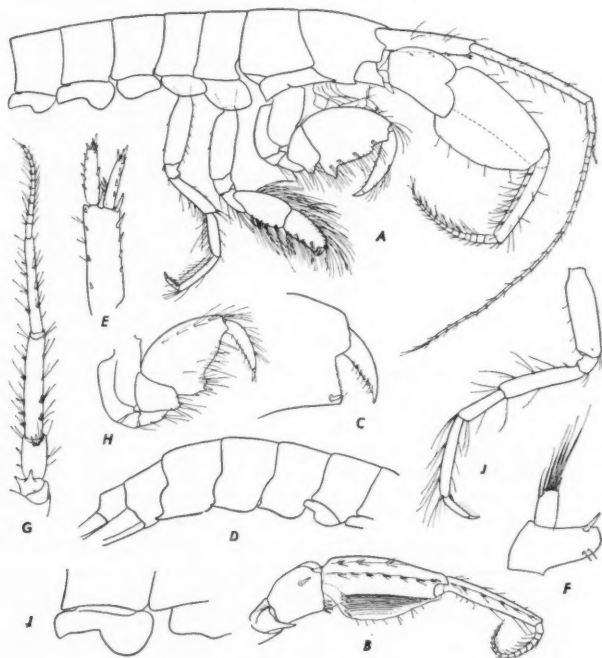


Fig. 4. *Unciola laticornis* Hansen. Male. a, anterior half of animal; b, left antenna 2, ventral side; c, palm and seventh joint of gnathopod 2; d, urosome segments; e, uropod 1; f, uropod 3. Female. g, left antenna 2, ventral side; h, gnathopod 1; i, coxal-plate 5; j, peraeopod 4.



pod 1. The ventral surface of antenna 2 is as shown by my figure (4g). The gland-cone and the lateral tooth of the second joint are very prominent; the third joint bears 2 distal spines and 2 inner lateral spines; the fourth joint bears spines on the inner margin, and 2 spines proximally near the outer margin; fifth joint bears spines on inner margin, but none on outer margin; flagellum composed of from 12 to 14 joints. Gnathopod 1, palm with only a mere suggestion of a distal protuberance, and the defining lobe is low and long and bears 1 stout spine and 1 slender spine. Length about 10 mm.

Most of the specimens in the National Museum collection were taken by the *Albatross* and they range from east of Nova Scotia,  $45^{\circ} 04' \text{ N.}$ ,  $59^{\circ} 36' \text{ W.}$ , to the waters off Virginia,  $37^{\circ} 38' \text{ N.}$ ,  $73^{\circ} 16' \text{ W.}$  The shallowest depth, 57 fathoms, is off Nova Scotia and the greatest depth, 1769 fathoms, is off New Jersey. This appears to be a deep water species, as it was frequently taken below 1000 fathoms.

#### UNCIOLA LAMINOSA Pearse

Fig. 5

1912. *Unciola laminosa* Pearse, Proc. U. S. Nat. Mus., vol. 43, No. 1936, p. 377, fig. 7.

Dr. A. S. Pearse described this species from 7 specimens taken by the *Albatross* at stations 2369-2374 ( $29^{\circ} \text{ N.}$ ,  $85^{\circ} \text{ W.}$ ), and 1 specimen taken at Punta Rassa, Charlotte Harbor, Florida. I have not been able to find the 7 *Albatross* specimens studied by Dr. Pearse, but I have found among the unidentified material in the National Museum collection many fine specimens of this species taken at stations 2369-2374. The type, taken at Punta Rassa, was dissected by him for study and is in very poor condition. As the type studied and figured by Dr. Pearse was a male, I am here describing and figuring the female. Some of the characters shown by Dr. Pearse's figures are not quite correct according to the males which I have studied. I am, therefore, figuring some of the important appendages of the male.

*Female*.—Head with rostrum of moderate length; on either side of the rostrum and partly over the lateral lobe of the head is a low forward-projecting lobe; lateral lobe with upper corner rounding and lower corner angular; eye not very well defined and consisting of a few dark facets. On the front of the head just below the rostrum there is a prominent columnar process with a concave outer surface. From the side this process somewhat resembles the head of a bird.

Antenna 1, first joint stoutest, armed below with 2 or 3 spines, and on the inner margin with from 3 to 5 spines; second joint a little longer than the first; third joint over half the length of the second; flagellum of about 8 joints; accessory flagellum very minute and consisting of a longer joint and an extremely small terminal joint. Antenna 2 is very elaborately developed; third joint greatly expanded from top to bottom and also laterally, upper margin produced forward into a narrow process armed distally with a tooth or spine, front, outside lateral margin forming a rounding crenulate lobe, the inner margin of the upper forward-pointing lobe curves back across the top

of the joint and is then continued downward in a broad rounding curve to form the inner front margin of the joint, the outer and inner margins of this curve are armed with short stout spines; fourth joint with outer margin divided in the middle by a deep sinus into 2 lobes the proximal of which bears a distal apical spine, inner margin of joint produced forward into a prominent lobe bearing a strong distal spine, and the inner margin is also

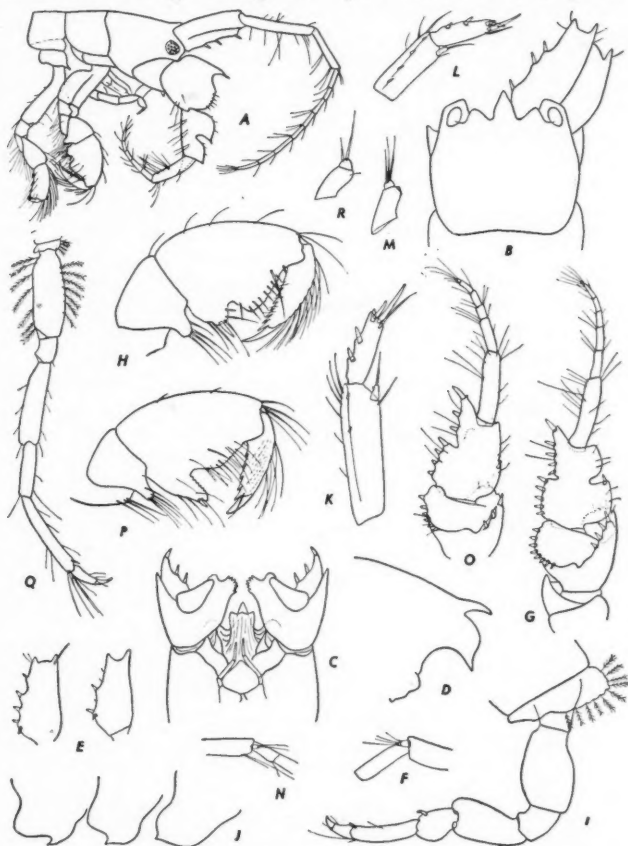


Fig. 5. *Unciola laminosa* Pearse. Female. a, anterior part of animal; b, head, dorsal view; c, head, ventral view showing rostrum and columnar process; d, rostrum and columnar process from the side; e, dorsal view, first peduncular joint of antenna 1 of two females; f, accessory flagellum; g, right antenna 2, dorsal view; h, gnathopod 1; i, peraeopod 3; j, metasome segments; k, uropod 1; l, uropod 2; m, uropod 3. Male. n, accessory flagellum; o, right antenna 2, dorsal view; p, gnathopod 1; q, peraeopod 5; r, uropod 3.

divided into 2 lobes by a rather shallow sinus, the entire inner margin armed with short stout spines; fifth joint a little shorter than the fourth and unarmed; flagellum consisting of about 5 joints.

Mouth-parts rather closely conforming to the pattern of *U. irrorata*; maxilliped, inner plate with 3 apical teeth and the outer plate with 4 or 5 marginal teeth and 4 curved distal spines. Maxilla 2 normal. Maxilla 1, inner plate with 2 plumose setae, outer plate with 9 spine-teeth, palp with 4 spine-teeth and several setae. Mandible and lower lip normal. Gnathopod 1 short but strongly built, sixth joint with palm crenulate and indented by a rather deep angular sinus, defining lobe armed with a stout spine; seventh joint with inner curved margin bearing forward-pointing serrations and apex of joint closing against the defining lobe of palm. Gnathopod 2 with palm of sixth joint transverse, finely serrate and bearing a short spine at the defining angle; seventh joint with 3 teeth on inner margin.

Peraeopods 1 and 2 slender. Peraeopods 3 to 5 only slightly expanded. Coxal-plates 1 to 4 produced a little forward. Coxal-plate 5 deeper in front than behind, but scarcely forming a lobe. Metasome segments produced below into angular processes as shown by my figures. Uropod 1, peduncle without a distal triangular process. Inner ramus of uropods 1 and 2 greatly reduced. Uropod 3 not extending beyond telson, and is as shown by my figure. Length from rostrum to end of uropods about 5 mm.

*Male*.—The male appears to be like the female except in the second antenna and the first gnathopod. In the second antenna the outer margin of the fourth joint is not divided into 2 lobes by a deep sinus, but has only a very shallow depression (or in some specimens no depression at all) accompanied by a short curved spine; the inner margin of the joint is much like that of the female but does not have so many spines. In gnathopod 1 the defining lobe of the palm is very prominent and bears a distal spine, the adjoining sinus is very deep leaving a low, convex palm; the seventh joint is armed with only 5 teeth on lower margin. Length of male from rostrum to end of uropods 3.5 mm.

There are in the National Museum collection many specimens taken by the *Albatross* at stations 2369-2374, 29° N., 85° W., Feb. 7, 1885, in 26 fathoms; 25 specimens taken at station 2405, 28° N., 85° W., in 30 fathoms; and 15 specimens taken at station 2406, 28° N., 84° W., in 26 fathoms. One specimen was taken by the *Bache* at Cedar Keys, Florida, Feb., 1887. Eight specimens were taken by the Hancock Expeditions at station A14, south of Cape La Vela on the Caribbean coast of Colombia, April 8, 1939, in 21-22 fathoms.

This species is not known definitely outside of the Gulf of Mexico and the Caribbean Sea. A few specimens of *Unciola* were taken by the Hancock Pacific Expeditions at the Secas Islands in the Bay of Panama and at Petatlan Bay on the west coast of Mexico. As these specimens differ slightly in some of their characters from *U. laminosa*, it will not be possible to determine their correct status until further material is secured. However, these specimens constitute the first record of the occurrence of the genus *Unciola* on the west coast of America.

*Unciola inermis*, new species

Fig. 6

*Male*.—Body dorsally broad and flattened; first segment longer than the following segments. Head, rostrum rather long and acute, and continued down the front of head as a keel incised near the top by a prominent sinus; lateral lobes quadrate; eye oval and black. Antennae much as in *U. irrorata*, but not so strongly developed. Antenna 1 longer than antenna 2, first joint shorter and stouter than second, which is over twice the length of the third; first joint bearing several spines on inner margin, and 1 distal spine and 2 or 3 proximal spines on lower margin; second joint without spines, but bear-

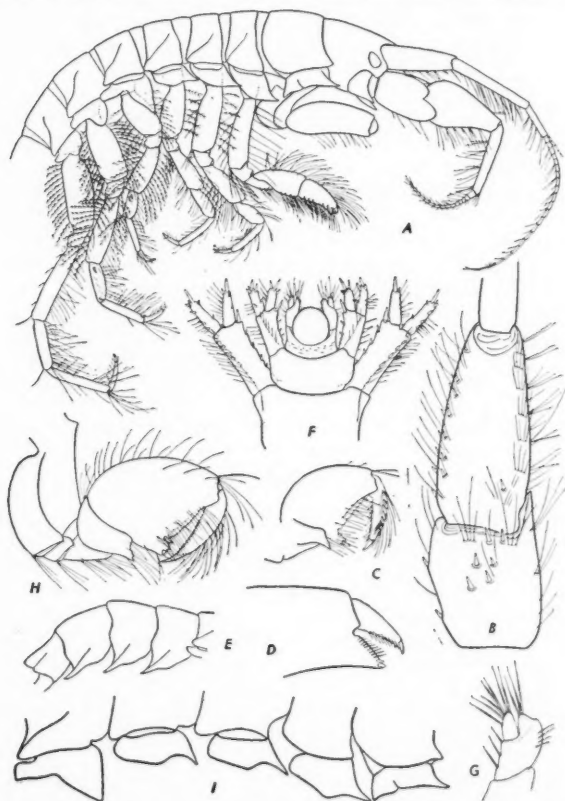


Fig. 6. *Unciola inermis*, new species. Male. a, anterior half of animal; b, left antenna 2, ventral side; c, gnathopod 1; d, palm and seventh joint of gnathopod 2; e, metasome segments; f, urosome and appendages; g, uropod 3. Female. h, gnathopod 1; i, coxal-plates 1 to 5.

ing groups of slender setae; flagellum of 18 to 22 joints, accessory flagellum of 4 regular joints and a very short terminal joint. Antenna 2, gland-cone very prominent; third joint with 3 or 4 small spines on ventral surface, 1 or 2 small spines at the front ventral margin, and 1 or 2 small spines on the inner surface; fourth joint, inner margin without serrations, but bearing a double row of small spines accompanied by groups of setae, and inner front margin not produced as in *U. irrorata*, lower outer margin sharp and bearing groups of setae, upper outer margin sharply angular; fifth joint, lower margins without spines but bearing groups of setae; flagellum of 12 to 14 joints.

Mouth-parts very much as in *U. irrorata*. Mandible with 2 spines in spine-row. Maxilla 1, inner plate with 2 or 3 plumose setae. Maxillipeds, inner plate with 3 teeth on upper edge and a hooked spine at upper inner edge; outer plate with 8 teeth on inner edge.

Gnathopod 1, palm straight and without tooth or protuberance. Gnathopod 2, palm more chelate than in *U. irrorata*. Peraeopods 1 and 2 alike, but 1 and a little the longer. Peraeopods 3 to 5 increasing consecutively in length, their second joint slightly expanded; seventh joint long and slender. Coxal-plates 1 to 4 produced sharply forward at the lower front corner; coxal-plate 5 produced downward in front to a long, pointed triangular lobe; coxal-plates 6 and 7 produced downward into a rounding lobe. Metasome segments 1 to 3 produced downward into long sharp angles. Uropods and telson are as I have shown in my figure. Peduncle of uropod 1 bears distally below a very small triangular lobe which is scarcely perceptible in some specimens. The ramus of uropod 3 is usually a little longer than the peduncular lobe. Length from rostrum to end of uropods about 11 mm.

*Type*.—A male, U. S. National Museum No. 81534, taken by the U. S. Str. *Speedwell* at station 149, August 3, 1878, off Baker's Island, Massachusetts Bay, in 19½ fathoms, bottom sand and gravel.

*Female*.—The female is very much like the male, differing principally in the second antenna. Antenna 1 is armed as in the male. Antenna 2, slender; third joint with 2 or 3 small spines on ventral surface, 1 or 2 small spines at the front ventral margin, and 1 or 2 small spines on inner surface; fourth joint with double row of small spines accompanied by setae on inner margin; fifth joint with a single row of spines and setae on inner margin. The first body segment is not as long as in the male. First 4 coxal-plates inclined to be more sharply produced in front, and the fifth not produced downward as much as in male. Length from rostrum to end of uropods about 12 mm.

The most northern record for *U. inermis* is 44° 29' N., 52° 53' W. These specimens were taken from the stomach of a fish and were sent to the National Museum for identification by the Biological Board of Canada. This species is well represented in the Bay of Fundy and the waters of New England down to Block Island Sound. There are no records farther south except for a few small specimens taken at the mouth of Chesapeake Bay by

the *Fish Hawk* in 1920. *U. inermis* appears to be a shallow water species, occurring from low tide down to 100 fathoms, but the great majority of records are from low tide to about 30 fathoms.

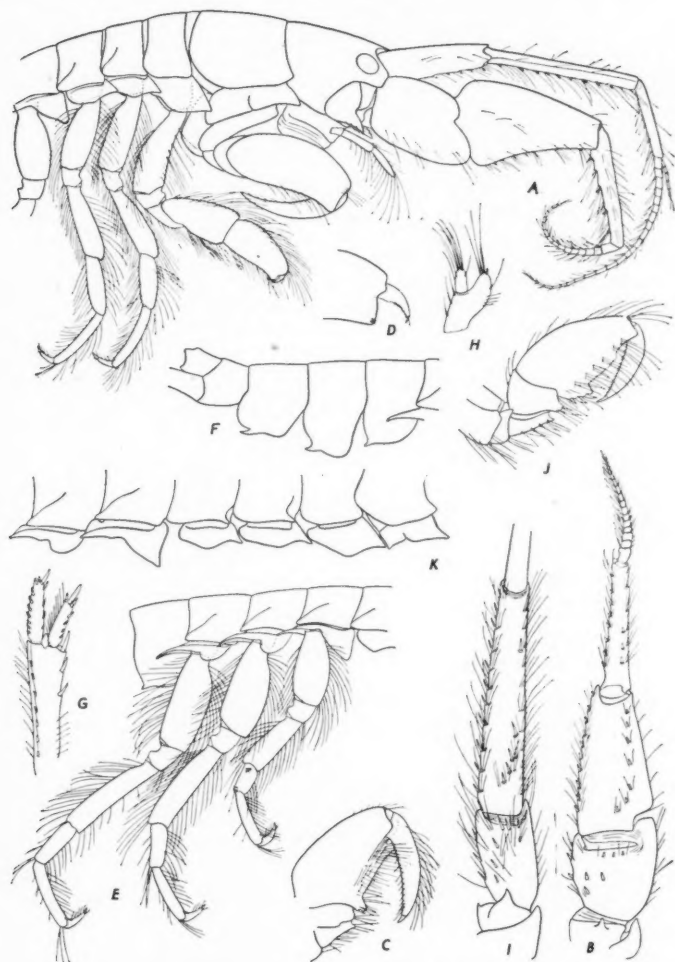


Fig. 7. *Unciola spicata*, new species. Male. a, anterior half of animal; b, left antenna 2, ventral side; c, gnathopod 1; d, palm and seventh joint of gnathopod 2; e, pereopods 3 to 5; f, metasome segments; g, uropod 1; h, uropod 3. Female. i, left antenna 2, ventral side; j, gnathopod 1; k, coxal-plates 1 to 6.

*Unciola spicata*, new species

Fig. 7

*Male*.—Body dorsally broad and flattened; first segment longer than the following segments. Head, rostrum rather long and acute and continued down the front of the head as a keel similar to that of *U. irrorata*. Eye oval and light straw color in alcoholic specimens. Mouth-parts as in *U. irrorata*. Antenna 1, first joint armed on the under margin with 6 or 7 small spines, and on the inner margin with 10 or 11; second and third joints bearing spines on lower margin; flagellum of from 19 to 25 joints, and accessory flagellum with 5 joints. Antenna 2 strong and robust, second joint with gland-cone not strongly developed; third joint with several small spines below and 2 on inner margin, the distal, ventral, movable spine is not as strongly developed as in *U. irrorata*; fourth joint bearing a few submarginal spines on ventral surface, inner ventral margin serrate and spinose, a longitudinal row of small spines on inner surface above lower inner margin; fifth joint bearing a few submarginal spines on ventral surface, and inner ventral margin serrate and spinose; flagellum of 14 or 15 joints.

Gnathopod 1, palm straight, produced forward distally into a blunt round-ing tooth, and defined by a blunt lobe bearing a small spine on the proximal margin. Gnathopod 2, palm nearly transverse and bearing 2 small spines at the defining angle. Peraeopods 1-5 are as shown by my figures. Coxal-plates 1-4 produced slightly forward and downward into a rather narrow angle. Coxal-plate 5 with front lobe produced triangularly downward, and hind lobe produced backward considerably beyond the body segment into a long narrow, downward-curving sharp point. Coxal-plates 6 and 7 with front lobe shallow and rounding and hind lobe produced sharply backward as in plate 5. Meta-some segments 1-3 produced below into a tooth as shown by my figures.

Uropod 1, peduncle produced distally below into a prominent triangular tooth or lobe. Uropod 3 as shown by figure 7h. Telson as in *U. irrorata*. The coxal-plates, peraeopods, and metasome segments are fringed with plumose setae. Length from rostrum to end of uropods about 16 mm.

*Type*.—A male, U. S. National Museum No. 81535, taken by the *Albatross* at station 2537, 39° 45' N., 70° 50' 30" W., August 7, 1885 at a depth of 156 fathoms.

*Female*.—The female appears to attain a slightly larger size than the male, the largest measuring about 18 mm. Coxal-plates 5-7 are not produced backward so much or so sharply as in the male. Antenna 2 with 2 rows of spines on inner margin of fourth joint. In gnathopod 1 the palm is not produced forward into a tooth, and the hind margin of the joint is rather long and bears 3 spines in the largest females, but only 1 or 2 in smaller females.

*Unciola spicata* has been taken at 40° 05' N., 70° 35' W., off the coast of New Jersey and southward to the mouth of Chesapeake Bay where a few specimens were taken by the *Fish Hawk* in 1920. One male was taken at *Albatross* station 2644, off the southeast coast of Florida (25° 40' N., 80°



00' W.) at 193 fathoms. This species in all probability occurs along the intervening coast, but has not been recorded, as the amphipod fauna of our southeast coast has been little explored. The depths given for this species are from 20 to 444 fathoms, but the great majority of records are around 100 fathoms.

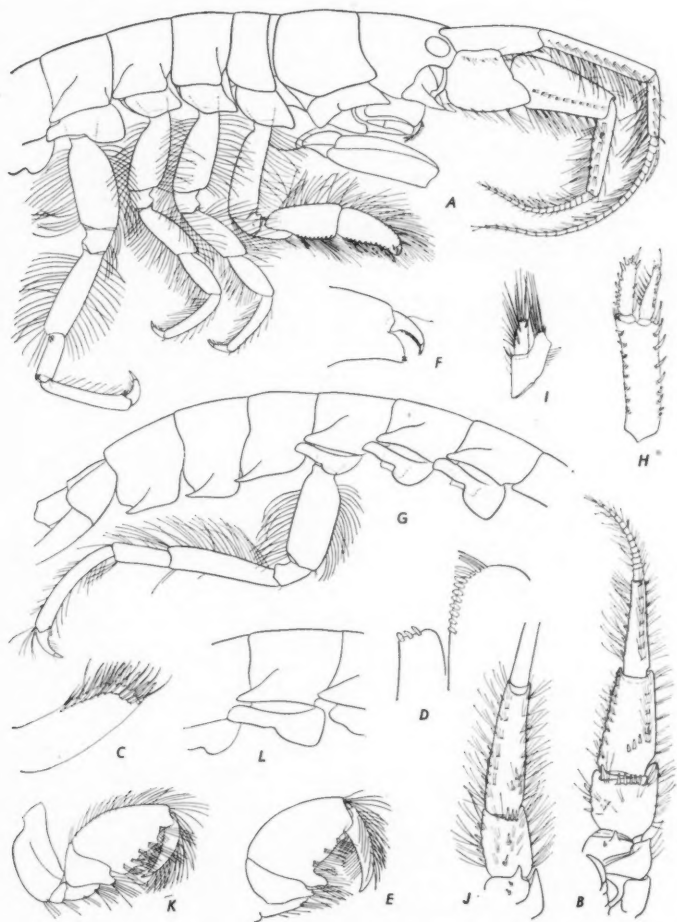


Fig. 8. *Unciola dissimilis*, new species. Male. a, anterior half of animal; b, left antenna 2, ventral side; c, palp of maxilla 1; d, teeth of maxilliped; e, gnathopod 1; f, palm and seventh joint of gnathopod 2; g, posterior part of animal; h, uropod 1; i, uropod 3. Female. j, left antenna 2, ventral side; k, gnathopod 1; l, coxal-plate 5.

*Unciola dissimilis*, new species

Fig. 8

*Male*.—Body dorsally broad and flattened; first segment longer than the following segments. Head, rostrum rather long and acute, and continued down the front of the head as an incised keel as in *U. irrorata*; lateral lobes more or less quadrate with upper corner more angular than the lower; eye oval and brownish in alcoholic specimens. The proportions of the antennae are as shown by my figures. Antenna 1, inside margin of first joint bearing a row of 6 or 7 short spines which does not appear to reach to the distal end of joint, lower margin bearing about 4 proximal short spines and a stouter distal spine; second and third joints without spines, but bearing numerous groups of setae; flagellum of about 28 joints; accessory flagellum of 5 joints. Antenna 2 not so strongly developed as in some species of the genus; third joint armed on ventral surface with a row of 4 or 5 stout distal spines and a stout but rather short movable distal spine, 2 short spines are situated toward the inner ventral margin, and the inner margin of the joint is armed with 3 stout spines, the lower distal lobe of third joint is only moderately developed; fourth joint not greatly developed, being not as deep from top to bottom as the third joint, armed on the proximal ventral surface with 3 stout spines, and on the inner margin with a row of short spines and setae above which is another row of spines and setae; fifth joint armed on inner margin with a row of spines and setae; flagellum of from 13 to 19 joints.

Mouth-parts about as in *U. irrorata*. Gnathopod 1 resembling that of *U. i.*, but the distal tooth of palm is somewhat less prominent, and the defining lobe does not bear a spine except in the oldest males. In gnathopod 2 the palm is convex, decidedly chelate, and bears 2 small spines at the defining angle. The pereopods are as shown by my figures. Coxal-plates 1-4 not produced forward into sharp points, but are only bluntly rounded. Coxal-plate 5 is not produced triangularly downward as in *U. spicata*, but is rather shallow with the top and bottom margins nearly parallel. The hind lobe of coxal-plates 5-7 is evenly rounding posteriorly and extends only a little beyond the body segment. The margins of the coxal-plates and pereopods and the lower margin of the metasome segments are densely clothed with plumose setae. Uropods and telson much like those of *U. irrorata*. Length from rostrum to end of uropods about 15 mm.

*Type*.—A male, U. S. National Museum No. 81536, taken by Horace G. Richards at Hen and Chicken Shoal, off Rehoboth, Delaware, May 29, 1931, at a depth of 21 fathoms.

*Female*.—The female differs from the male principally in the second antenna and the first gnathopod. The third joint of antenna 2 bears 1 or 2 spines on ventral surface, 3 or 4 spines on distal ventral margin, and 3 to 5 spines on inner margin; fourth joint with 2 spines proximally on ventral surface near the outer margin, and with 2 rows of spines and setae on inner margin; fifth joint with single row of spines on outer margin. Gnathopod 1, palm short and bearing a low protuberance distally, defining lobe or hind margin

of joint rather long and armed with 2 stout spines; seventh joint armed on lower concave edge with very fine serrations and setae, and on the upper margin with numerous forward-curving setae. In coxal-plate 5 the front lobe is somewhat shallower and broader than in the male. The females seem to reach a little larger size than the males, the largest measuring about 16 mm. from rostrum to end of uropods.

According to the records in the National Museum, *U. dissimilis* ranges from Cape Ann, Massachusetts to Beaufort, North Carolina, and has been taken from low tide down to 547 fathoms.

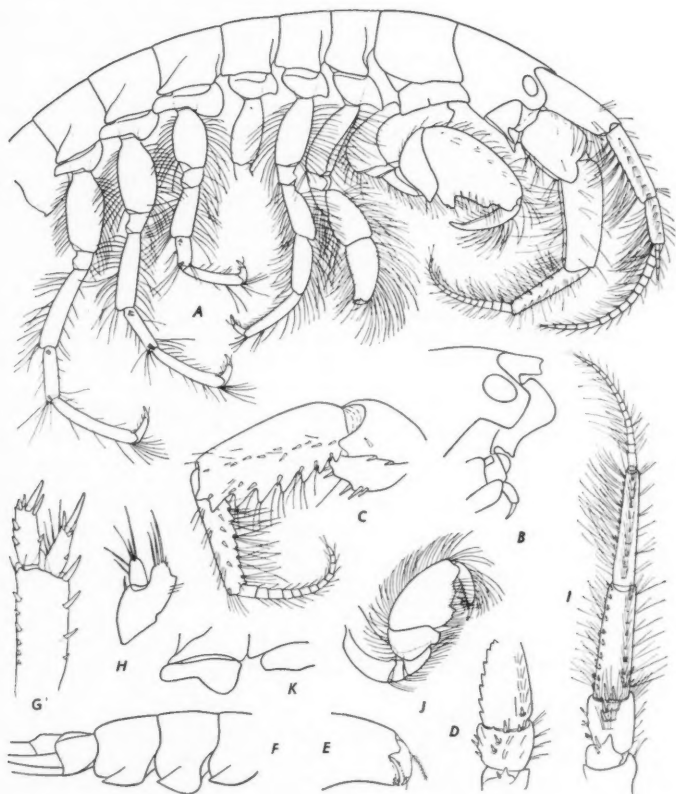


Fig. 9. *Unciola serrata*, new species. Male. a, anterior part of animal; b, head, showing epistome; c, right antenna 2, inner surface; d, left antenna 2, ventral side; e, palm and seventh joint of gnathopod 2; f, metasome segments; g, uropod 1; h, uropod 3. Female. i, left antenna 2, ventral side; j, gnathopod 1; k, coxal-plate 5.

*Unciola serrata*, new species

Fig. 9

*Male*.—Head, rostrum rather prominent; side lobes with sides nearly parallel and corners rounding; eye oval and brownish in alcoholic specimens. Antenna 1, first joint a little longer than second, inside margin armed with 7 spines and lower margin with 3 or 4 spines; second joint without spines on outside margin and sometimes 1 or 2 proximally on the inside margin; third joint over half the length of the second; flagellum shorter than peduncle and composed of about 14 joints; accessory flagellum of 4 normal joints and a very small terminal joint. Antenna 2 not as robust as in some species; gland-cone of second joint bearing a spine at its base; third joint armed with 3 spines on inside margin, an oblique row of 2 or 3 spines on ventral surface and 2 spines on distal ventral margin; the distal movable spine of this joint is not present in this species, but in its place is a low inconspicuous protuberance; fourth joint bearing a proximal spine on the ventral surface near the outer margin, lower inner margin bearing very strong serrations and a row of spines above which on inner surface of joint is another row of spines; fifth joint bearing serrations on the lower inner margin and a row of spines on inner surface; flagellum short and consisting of from 12 to 14 joints.

Mouth-parts not differing materially from those of *U. irrorata*. Gnathopod 1 much like that of *U. irrorata*; the palm bears a low distal tooth and the proximal defining lobe bears a small spine. Gnathopod 2 decidedly chelate, palm convex, very finely serrate and bearing 2 distal spines on the inside surface at the defining angle; seventh joint fitting palm and serrate on inner margin. Peraeopods resemble those of *U. irrorata*, and are as shown by my figure. Coxal-plates 1 to 4 produced slightly forward and downward; coxal-plates 5 to 7 with front lobe rounding and shallow, hind lobe rounding and not projecting much beyond the body segment. All the coxal-plates and peraeopods fringed with plumose setae.

Metasome segments 1 to 3 bearing a small tooth at the lower hind corner. but in segment 3 the tooth appears to be on the lower margin. Uropods 1 and 3 are as shown by my figures. Length from rostrum to end of uropods about 7 mm.

*Type*.—A male, U. S. National Museum No. 81537, taken by the steamer *Fish Hawk* in the west end of Skull Creek, Port Royal Sound, South Carolina, January 21, 1891.

*Female*.—The female resembles the male except in the second antenna and the first gnathopod. The under surface of antenna 2 is as follows: second joint with gland-cone very prominent and bearing 1 or 2 spines at its base; third joint with 5 spines on inner margin, 2 spines on the under surface and 2 spines on distal margin; fourth joint with 2 rows of spines on inner margin and 1 or 2 spines proximally on the outer margin; fifth joint with a row of spines on inner margin. Flagellum consisting of about 14 joints. The

palm of gnathopod 1 is short and has a low median protuberance instead of the distal tooth of the male, and the long defining lobe or hind margin of joint bears a prominent spine. Length from rostrum to end of uropods about 8 mm.

*Unciola serrata* is a small species and one is at once struck with the hairy and plumose appearance of the animal. There are records of the occurrence of this species from Vineyard Sound, Massachusetts to St. Simons Island, Georgia. It has been taken at Sea Isle City, New Jersey; in the lower part of Chesapeake Bay; 2 miles off Charleston, and in the estuaries of South Carolina; and at the base of the piling of the city dock, St. Simons Island, Georgia. The depths for most of the records are not stated, but most of the occurrences are in shallow water.

U. S. NATIONAL MUSEUM,  
WASHINGTON, D. C.

## Two New Species of Crayfishes of the Genus *Cambarellus* from the Gulf Coastal States, With a Key to the Species of the Genus (Decapoda, Astacidae)

Horton H. Hobbs, Jr.<sup>1</sup>

One of the characteristics of the genus *Cambarellus* is the very small size of all known species. Only a few other crayfishes, such as *Procambarus youngi* Hobbs and *Orconectes clypeata* (Hay) which are pygmies in their own genera, are as small as the larger members of *Cambarellus*. For this reason they are commonly either overlooked by collectors, or regarded as immature specimens and consequently ignored. This genus is poorly known throughout its range, and the extent of its wide distribution in the United States has not been realized.

For a number of years I used a coarse-meshed dipnet and seine almost exclusively for they could be moved rapidly, and would retain any of the known crayfishes in Florida. However, on one occasion a specimen of *Cambarellus schmitti* was accidentally taken in a coffee-sieve from a small stream in the southern part of Walton County, Florida, and it was obvious that specimens of this size could hardly be collected in the type of net I was using. Now I have discarded the coarse-meshed nets for general collecting for one made of strong, 1/16" mesh scrim, and am finding that these small crayfishes occur in some numbers throughout the states bordering the Gulf and lower Mississippi River.

Three new species (including *C. schmitti*<sup>2</sup>) have been discovered in this area. Upon reviewing the literature, and examining specimens of all known members of the genus, the species are found to fall into three somewhat natural groups. For convenience in expressing their affinities, I am subdividing the genus *Cambarellus* into the Schmitti, Shufeldtii, and Montezumae Sections, based on the structure of the first pleopod of the male. In the key which follows, the diagnostic characters of these sections are given.

One of the two species herein described was collected in Mobile County, Alabama and Jackson County, Mississippi; the other in Liberty County, Texas. Both of these species belong to the Section of *Cambarellus schmitti*.

### KEY TO THE SPECIES OF THE GENUS CAMBARELLUS

- 1 Terminal elements of first pleopod of first form male straight (see fig. 3)  
.....Section of *C. shufeldtii* containing a single species, *C. shufeldtii* (Faxon)

<sup>1</sup> Contribution from the Department of Biology, University of Florida.

<sup>2</sup> Hobbs, H. H. 1942—The Crayfishes of Florida, Univ. Fla. Pub., Biol. Series, 3(2):149-153, figs. 176-180, 286-295.

- 1' Terminal element of first pleopod of first form male bent (directed caudo-distad) (see figs. 2, 4, 14) ..... 2
- 2(1') Mesial process of first pleopod of first form male trough-like (see fig. 4).....  
.....Section of *C. montezumae* containing a single species, *C. montezumae*<sup>3</sup>
- 2' Mesial process of first pleopod of first form male not trough-like, but blunt or spiniform (see figs. 2, 14).....Section of *C. schmitti*..... 3
- 3(2') Lateral spines on carapace small or absent. Areola five to six times longer than broad. Mesial process of first pleopod bent at approximately an 80 degree angle to the main shaft of the appendage.....*C. puer* sp. nov.
- 3' Lateral spines present on side of carapace. Areola two to four times longer than broad. Mesial process of first pleopod bent at less than an 80 degree angle to the main shaft of the appendage ..... 4
- 4(3') First form male with bituberculate hooks on ischiopodites of second and third pereopods; caudal process of first pleopod subspiculiform; central projection scythe-like. Areola about three times as long as broad. Annulus ventralis decidedly broader than deep.....*C. schmitti* Hobbs
- 4' First form male with bituberculate hooks on ischiopodites of third pereopods only, those on second simple; caudal process of first pleopod acute but definitely not spiculiform; central projection subtriangular. Areola about twice as long as broad. Annulus ventralis subequal in breadth and depth .....*C. diminutus* sp. nov.

#### *Cambarellus diminutus* sp. nov.

*Diagnosis.*—Areola broad, only twice as long as wide, with seven or eight punctations in narrowest part; first form male with hooks on second and third pereopods, those on third bituberculate, those on second simple; palm of chela smooth; postorbital ridges terminating cephalad in long spines which extend cephalad of the cephalolateral margins of carapace; a strong lateral spine on either side of carapace. First pleopod of first form male extending to coxopodite of third pereopod and terminating in three distinct parts; mesial process noncorneous, thumb-like, and closely applied to and obscured in lateral aspect by the caudal process and central projection; caudal process noncorneous, acute and extending beyond the other terminal elements caudodistad; central projection corneous and subtriangular. Annulus ventralis of female subequal in width and depth; sub-disc shaped.

*Holotypic Male, Form I.*—Body in cross section subovate, compressed laterally. Width of abdomen and carapace subequal. Width and depth of carapace in region of caudodorsal margin of cervical groove subequal. Greatest width of carapace immediately caudad of caudodorsal margin of cervical groove.

Areola wide (twice as long as wide) and approximately 27% of entire length of carapace; eight or nine punctations in narrowest part; sides subparallel in middle.

Rostrum broad; surface concave cephalad, punctate, sides slightly convergent (not convex laterad); ridges not prominent. Lateral spines long and slender. Acumen spiculiform, setiform, and extending cephalad to base of flagella of antennules. Postorbital ridges terminate cephalad in long spines

<sup>3</sup> The several subspecies of *montezumae* are so inadequately known that it seems best to refrain from attempting to separate them here.



which extend cephalad beyond the cephalolateral margin of carapace. Subrostral ridges visible for some distance cephalad in dorsal aspect.

Surface of carapace punctate; lateral portions granulate. Strong lateral spines present. Suborbital angle acute and prominent. Branchiostegal spine strongly developed.

Abdomen longer than thorax. Anterior section of telson with two spines in each of the posterolateral corners.

Epistome (in ventral view) broadly rounded with cephalolateral margins raised.

Antennules of the usual form. A strong spine present on the ventromesial margin of basal segment.

Antennae extending caudad to caudal margin of second abdominal segment. Antennal scale large, broadest in middle. Spine on outer margin strong, extending cephalad to tip of rostrum.

First pereopod subovate, long, slender, with setiferous punctations, non-tuberculate. Opposable margins of both fingers with minute denticles and hairs. Neither finger with ridges.

Carpus longer than broad with scattered setiferous punctations and hairs. A single large spine present on lower cephalic margin.

Merus with one strongly developed acute spine on lower surface distad of midlength. Upper surface with a strong spine on distal third; a strong spine present on distolateral margin.

Ischiopodites of second and third pereopods with hooks; hook on second simple; that on third bituberculate; tubercles subequal in size.

Coxopodite of fourth pereopod with no conspicuous prominence; however, coxopodite of fifth pereopod with a strong one directed cephalad.

First pleopod reaching coxopodite of third pereopod. Tip terminating in three distinct parts. Mesial process, the shortest of the three, noncorneous and closely applied to the mesial surfaces of other two processes (in lateral aspect obscured by them), somewhat bulbous and thumb-like. Cephalic process absent. Caudal process arises from the caudolateral margin, is noncorneous, more acute than the mesial process, and extends beyond the other terminal elements caudodistad. Central projection, the largest of the three, corneous, acute, and directed caudodistad. The whole tip is directed caudodistad.

*Female Allotype*.—Width of abdomen greater than that of carapace. Greatest width of carapace immediately cephalad of caudodorsal margin of cervical groove. Surface flattened cephalad. Annulus ventralis movable, subdisc shaped. Sinistro-lateral margin with an oval furrow (see fig. 12). Sternum immediately caudad to annulus raised into an acute prominent tubercle.

*Male, Form II*.—Differs from the holotype in the following respects: Rostrum slightly shorter and surface more flattened than in holotype. Hooks on ischiopodites of second and third pereopods reduced; however, those on third bituberculate. First pleopod with all processes more truncated and bulbous, and none corneous.

*Measurements*.—Male (form I) Holotype: carapace, height 3.0, width

3.1, length 7.4 mm.; areola, width 1.0, length 2.0 mm.; rostrum, width 1.0, length 2.4 mm.; abdomen, length 10.0 mm.; right chela, length of inner margin of palm 2.3, width of palm 1.4, length of outer margin of hand 6.3, length of movable finger 2.3 mm. Allotypic female: carapace, height 3.5, width 3.1, length 7.4 mm.; areola, width 1.0, length 2.1 mm.; rostrum, width 1.2, length 2.6 mm.; abdomen, length 11.0 mm.; right chela, length of inner margin of palm 2.1, width of palm 1.3, length of outer margin of hand 5.0, length of movable finger 2.3 mm.

*Type locality*.—A large clear sand-bottomed stream, 3.5 miles south of Irvington, Mobile County, Alabama. The predominant vegetation in the stream consisted of *Orontium*, *Vallisneria*, and *Potamogeton*. Specimens of *diminutus* were taken on a small island from a shallow pool connected with the main stream. The pool contained filamentous and spherical colonial algae, decaying leaves, and sticks.

*Additional localities*.—3.3 miles west of Grand Bay, Mobile County, Alabama, U. S. Highway 90 (here the crayfish were taken from a roadside ditch in an abundant growth of *Juncus*, *Nymphaea*, *Myriophyllum*, *Persicaria*, and algae); 6.3 miles west of Grand Bay, Alabama, in Jackson County, Mississippi (a single female was dug from a burrow a few inches deep in a drying roadside ditch).

*Disposition of Types*.—The male holotype, female allotype, and second form male paratype, U. S. N. M. no. 81554, are deposited in the United States National Museum. Two males, form I, and two males, form II, and two females are in the same collection. A male, form I, a male, form II, and a female are deposited in the University of Michigan Museum of Zoology; similar series are deposited in the Museum of Comparative Zoology and the Carnegie Museum. The remaining paratypes, 12 first form males, 20 second form males, 25 females, and five immature females are retained in my personal collection.

*Relationships*.—*Cambarellus diminutus* has its closest affinities with *C. schmitti*. The first pleopod resembles closely that of *schmitti* with the terminal processes similar both in form and arrangement; however, all three elements are considerably reduced.

#### *Cambarellus puer* sp. nov.

*Diagnosis*.—Areola relatively narrow, five to six times longer than broad, with three or four punctations in narrowest part; first form male with hooks on second and third pereopods, those on third bituberculate, those on second simple; palm of chela smooth; postorbital ridges terminating cephalad in long spines which extend cephalad of the cephalolateral margins of carapace; weak spines may or may not be present on sides of carapace. First pleopod of first form male extending to coxopodite of third pereopod and terminating in three distinct parts; mesial process noncorneous, slender and directed caudoventrad at about an 80 degree angle to the main shaft of the appendage; caudal process subspiculiiform and corneous; central projection corneous, slender, and shaped somewhat like a scythe blade. Annulus ventralis semi-ovate.

*Holotypic Male, Form I.*—Body in cross section subovate; slightly compressed laterad. Thorax and abdomen subequal in width.

Width of carapace in region of caudodorsal margin of cervical groove slightly less than depth (4.0-4.4 mm.). Greatest width of carapace slightly caudad of caudodorsal margin of cervical groove.

Areola relatively narrow—5.8 times as long as wide; 32% of entire length of carapace; punctate (about three or four in narrowest part); sides subparallel in middle.

Rostrum of moderate width and length; surface flat and punctate; sides converging; ridges not prominent. Lateral spines moderately developed. Acumen with a few long setae, spiniform, extending cephalad to base of distal segment of peduncle of antennule. Postorbital ridges terminate cephalad in strong spines which extend cephalad beyond the cephalolateral margin of carapace. Subrostral ridges visible for some distance cephalad in dorsal aspect.

Surface of carapace punctate. Lateral spines absent. Suborbital angle acute. Branchiostegal spine small.

Abdomen longer than thorax. Anterior section of telson with two spines in the right and one in the left posterolateral corners.

Epistome (in ventral view) as seen in fig. 7; margins slightly upturned.

Antennules of the usual form. A moderate spine present on the mesio-ventral margin of basal segment.

Antennae extending caudad to fifth abdominal segment. Antennal scale large, broadest in middle. Spine on outer margin strong, extending beyond tip of rostrum.

First pereopod subovate, swollen, slightly compressed dorso-ventrally, long, with setiferous punctations, non-tuberculate. Inner margins of both fingers with minute denticles and hairs. No ridge on either finger.

Carpus longer than broad with scattered setose punctations. An acute tubercle present on lower distal margin, otherwise unarmed.

Merus with an acute spine on distolateral margin, and a small spine on distal third of upper surface.

Ischiopodites of second and third pereopods with strong hooks. Those on third bituberculate, those on second simple.

Coxopodite of fourth pereopod with a distally directed hook.

First pleopod reaching coxopodite of third pereopod and terminating in three distinct parts. Mesial process noncorneous, slender and directed caudo-ventrad at approximately an 80 degree angle to the main shaft of the appendage. Caudal process arises from caudolateral margin, spiculiform and corneous. Central projection corneous, slender, and shaped somewhat like a scythe blade. Both the caudal process and central projection directed at approximately a 45 degree angle to the main shaft of the appendage.

*Allotypic Female.*—With the exception of the width of the abdomen being greater than that of the cephalothorax, the description of the first form male is adequate for the female. Annulus ventralis oval in caudal view, compressed in the longitudinal axis. Sinus originating on dextral cephalic surface, cuts the

oval ridge and turns sinistral on the caudal surface, curving gently dorsad. Sternum just caudad of annulus modified into a flattened subspiniform process which fits into a depression on the caudal face of the annulus when the latter is pressed against it.

*Male, Form II.*—The second form male differs from the male, form I, in only a few minor points. The hooks on the ischiopodites of the second and third pereopods are much reduced. The terminal elements of the first pleopod, while closely resembling those of the first form male, are all more truncate and none is corneous.

*Measurements.*—Male (form I): carapace, height 4.4, width 4.0, length 9.0 mm.; areola, width 0.5, length 2.9 mm.; rostrum, width 1.4, length 2.4 mm.; abdomen, length 11.5 mm.; right chela, inner margin of palm 3.0, width of palm 2.2, length of outer margin of hand 6.5, length of movable finger 3.1 mm. Female: carapace, height 5.6, width 5.5, length 11.5 mm.; areola, width 0.9, length 3.4 mm.; rostrum, width 2.0, length 3.0 mm.; abdomen, length 15.0 mm.; right chela, inner margin of palm 3.4, width of palm 2.5, length of outer margin of hand 7.7, length of movable finger 3.7 mm.

*Type Locality.*—Seven miles west of Dayton, Liberty County, Texas, on U. S. Highway 90. Roadside ditch among vegetation and dead broom-sage. All of the specimens were taken at night with the aid of a headlight. *Procambarus hinei* and *P. blandingii acutus* were taken at the same locality with *puer*.

*Disposition of Types.*—The male, form I, holotype, the female allotype and a paratype male, form II, are deposited in the United States National Museum (U. S. N. M. no. 81556). Of the remaining paratypes, one male, form I, one male, form II, and a female are deposited in the Museum of Comparative Zoology; one male, form I, and a female are deposited in the University of Michigan Museum of Zoology, and one male, form I, and a female in the Philadelphia Academy of Sciences; 23 males, form I, one male, form II, and 22 females are retained in my personal collection.

*Relationships.*—*Cambarellus puer* has its closest affinities with *C. schmitti*. More remotely it is related to *diminutus*, *shufeldtii* and the subspecies of *montezumae*. The structure of the first pleopod and the general body conformations point to very close relationship with *schmitti*.

*Variation.*—Considerable variation has been noted in this species, and while available material is too scanty to allow me to state that these variations are correlated with distribution, it seems advisable to indicate the greater deviations from the typical form. In the type series there are specimens with small spines on the carapace, whereas in the holotype the carapace is devoid of lateral spines; in certain specimens from Louisiana, the postorbital spines are more strongly developed than they are in the typical series; the mesial process of the first pleopod in some specimens is not so decidedly bent, approaching the angle attained in *schmitti*; the merus of the chela may or may not bear spines on the upper, lower and laterodistal surfaces. The best diagnostic characters for this species are the spiculiform or distinctly spiniform mesial process of the first pleopod of the first form male, and the relatively narrow areola. While there is some overlapping in respect to the latter character between some of the speci-

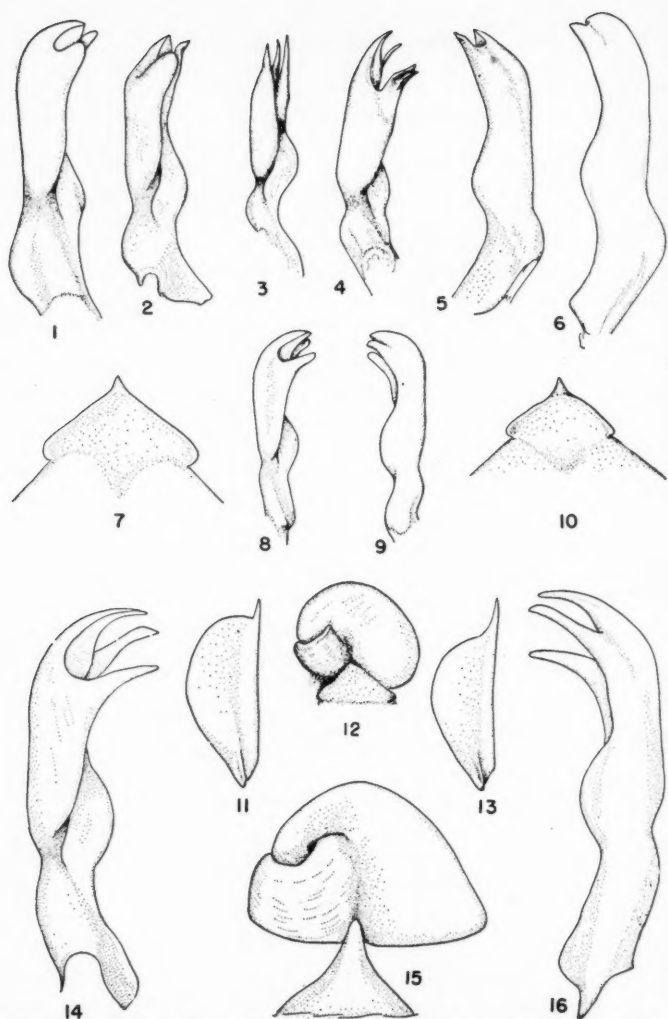


PLATE 1.—1. Mesial view of first pleopod of second form male *Cambarellus diminutus*. 2. Mesial view of first pleopod of first form male *C. diminutus*. 3. Caudomesial view of first pleopod of first form male *C. shufeldtii*. 4. Mesial view of first pleopod of first form male *C. montezumae montezumae*. 5. Lateral view of first pleopod of first form male *C. diminutus*. 6. Lateral view of first pleopod of second form male *C. diminutus*. 7. Epistome of *C. puer*. 8. Mesial view of first pleopod of second form male *C. puer*. 9. Lateral view of first pleopod of second form male *C. puer*. 10. Epistome of *C. diminutus*. 11. Antennal scale of *C. puer*. 12. Annulus ventralis of *C. diminutus*. 13. Antennal scale of *C. diminutus*. 14. Mesial view of first pleopod of first form male *C. puer*. 15. Annulus ventralis of *C. puer*. 16. Lateral view of first pleopod of first form male *C. puer*.

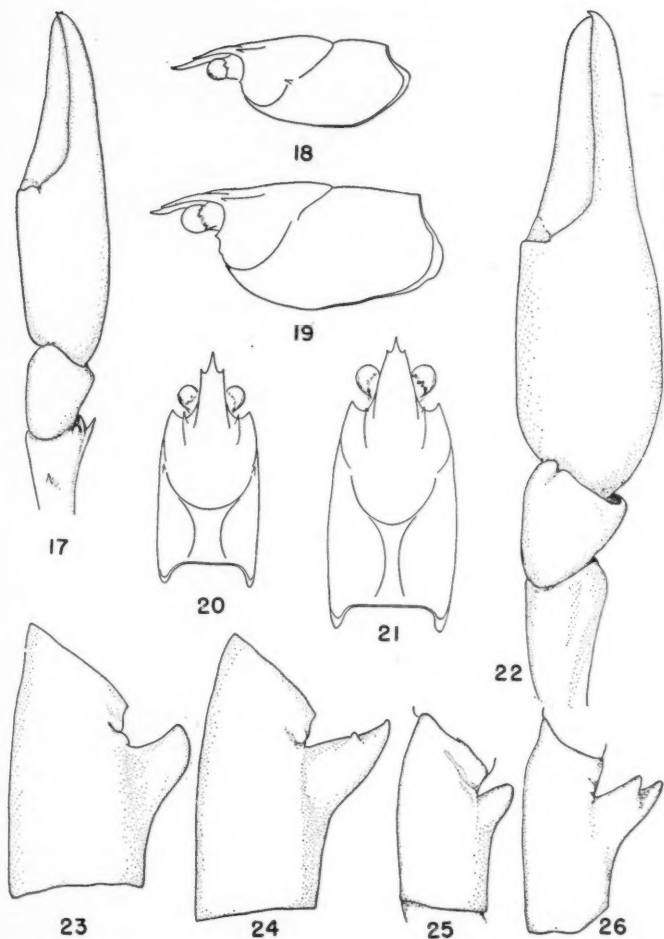


PLATE 2.—17, Upper view of merus, carpus, propus, and dactyl of first pereipod *Cambarellus diminutus* (male, form I). 18, Lateral view of carapace of *C. diminutus*. 19, Lateral view of carapace of *C. puer*. 20, Dorsal view of carapace of *C. diminutus*. 21, Dorsal view of carapace of *C. puer*. 22, Upper view of merus, carpus, propus, and dactyl of first pereipod *C. puer* (male, form I). 23, Ischiopodite of second pereipod of first form male *C. puer*. 24, Ischiopodite of third pereipod of first form male *C. diminutus*. 25, Ischiopodite of second pereipod of first form male *C. diminutus*. 26, Ischiopodite of third pereipod of first form male *C. diminutus*.

mens that I have ascribed to *puer* and specimens of *C. schmitti*, it is at least possible that these atypical specimens assigned to *puer* should be accorded subspecific or even specific rank.

*Distribution.*—*Cambarellus puer* seems to be wide spread in the southern parishes of Louisiana west of the Mississippi River,<sup>4</sup> and additional specimens of this species, or closely allied forms, have been collected from the following localities in Arkansas: 4.9 miles northeast of Paragould, St. Hy. 1, Green County; 13.4 miles west of Paragould, St. Hy. 25, Green County; 12.3 miles south of Lockesburg, U. S. Hy. 71, Howard County; and 7 miles east of Delhi, U. S. Hy. 80, Madison County.

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<sup>4</sup> A fine series of this species was collected from several parishes in the southern part of Louisiana by George H. Penn, Jr., who has kindly permitted me to examine these specimens.



## North American Triclad Turbellaria.

### XI. New, Chiefly Cavernicolous, Planarians

Libbie H. Hyman

Several years' accumulation of triclad material has furnished the occasion for this article. Although the material of fresh-water triclads sent me for identification frequently consists of common, well-known species, new forms turn up with sufficient frequency as to illustrate once more the paucity of knowledge of the fresh-water invertebrates of this country. Four of the five forms herein described are cavernicolous and add to the number of cave planarians of the United States, notable for their adhesive organ and for their excessive speciation, since each locality so far investigated harbors a different species. The North American cave planarians (for earlier descriptions, see Hyman, 1937b, 1939) comprise an array of forms not paralleled in any other country. They appear to have evolved endemically from the genus *Phagocata*.

#### Order TRICLADIDA

#### Suborder PALUDICOLA or PROBURSALIA

#### Family PLANARIIDAE

#### Genus PHAGOCATA Leidy 1847

#### *Phagocata gracilis monopharyngea*, new subspecies

Fig. 1

*Material*.—Many specimens sent by Dr. Leslie Hubricht.

*Form*.—Closely similar to *Phagocata gracilis* (illustrated in Kenk, 1935, Hyman, 1937a); large, broad, to 15 mm. long preserved, probably longer in life; anterior end truncate, without adhesive organ, with slightly indicated auricles.

*Color*.—Dark gray, judged from preserved specimens.

*Eyes*.—Somewhat irregular, two eyes or two main eyes, on or both accompanied by one or two small eyes.

*Digestive system*.—Single, somewhat elongated pharynx.

*Reproductive system*.—No testes found; animals appear spent; collected in April whereas usual breeding season of *Phagocatas* is late fall or early winter. Sperm ducts present posterior to pharynx; at level of penis bulb they turn dorsally and enter separately the penis bulb, opening separately into bulbar lumen (Fig. 1). Penis bulb rounded, moderately muscular, fibers

coursing mostly parallel to its external contour; bulbar lumen<sup>1</sup> rounded, continuous with broad ejaculatory duct proceeding to tip of conical penis papilla. Ovaries have well-developed parovaria; common ovovitelline ducts enters roof of male antrum, accompanied by eosinophilous cement glands. Copulatory bursa large, located just anterior to penis bulb, lined by tall wavy epithelium; canal proceeds posteriorly above male antrum, widens considerably distally and joins common antrum shortly behind entrance of ovovitelline duct (Fig. 1).

*Locality*.—Collected at the outlet of a tile drain, Haskins, Iowa, April 24, 1942.

*Type*.—One whole mount, A.M.N.H. no. 325. Cotype, set of serial sections of the copulatory apparatus (2 slides) A.M.N.H. nos. 326-327.

*Remarks*.—After some hesitation, I have decided to consider this form a subspecies of *Phagocata gracilis*. *Phagocata gracilis*, one of the most common planarians of the eastern United States, appears to be a polytypic species, i.e., one that is split up into geographic races (see Mayr, 1942, for a discussion of polytypic species). The typical form is polypharyngeal with a very muscular penis bulb and long slender penis papilla. It ranges from Virginia and Pennsylvania westward to the Mississippi and probably also southward but within this range shows some variation in small details of the copulatory apparatus (Kenk, 1935, Hyman, 1937a). Some years ago I distinguished the New England form under the name *woodworthi* (Hyman, 1937a), also polypharyngeal, and indistinguishable externally from *gracilis* but differing greatly in the details of the copulatory apparatus, especially in the short, truncate, less muscular penis. These two forms are certainly as different in the copulatory apparatus as any established species of planarians, but I found that transitional forms exist in New Jersey. Therefore *woodworthi* should probably be reduced to a subspecies of *gracilis* and the nominative form then becomes *Phagocata gracilis gracilis*. The present Iowa specimens appear to constitute a monopharyngeal variant of *P. g. gracilis*; their copulatory apparatus differs from that of the latter chiefly in the less muscular penis bulb and the shorter penis papilla.

#### Family KENKIIDAE

#### Genus SPHALLOPLANA Beauchamp 1931

#### *Sphalloplana alabamensis*, n. sp.

Figs. 2, 3

*Material*.—Two specimens sent by the U.S. National Museum.

<sup>1</sup> It is customary to term the cavity of the penis bulb seminal vesicle but as it does not serve for sperm storage in triclads (in fact sperm are never seen in it except during copulation), I propose hereafter to call this cavity the bulbar lumen. Other changes in terminology that I suggest for the Turbellaria in general are: sperm ducts in place of vasa deferentia, spermiducal vesicles for the enlarged parts of the sperm ducts usually called false seminal vesicles that actually are the true storehouses of sperm, bursal canal for the outlet of the seminal or copulatory bursa, antrum to replace altogether the over-worked term atrium; and for the triclads, ovovitelline ducts in place of oviducts.

*Form*.—Elongate, tapering to blunt posterior end; anterior end truncate with a central adhesive organ, no auricles; 5-6 mm. long; margin with exceptionally long rhabdites (Fig. 2).

*Color*.—Presumably white in life; preserved specimens brown.

*Eyes*.—Lacking.

*Adhesive organ*.—Similar to that of other members of the genus (Beauchamp, 1931, Hyman, 1939). Consists of an irregular depression lined with an altered epidermis permeated with the outlets of eosinophilous glands. Depression is surrounded by muscle fibers, mostly radial, that join both the dorsal and the ventral longitudinal muscles of the body wall. The organ is less muscular than that of other species of the genus.

*Copulatory apparatus*.—Distinguished by its excessive glandularity. Testes relatively few, prepharyngeal (Fig. 2). Sperm ducts enter separately beginning of the ejaculatory duct which forms a small rounded chamber (Fig. 3). From this duct runs through penis bulb without forming any enlargement. Penis short, rounded, with slightly muscular bulb; covering epithelium of the penis papilla tall and very glandular, filled with the outlets of subepithelial gland cells. Common oviduct enters roof of male antrum. Dorsal and rear wall of common genital antrum also very glandular, receiving outlets of numerous eosinophilous gland cells. Copulatory bursa relatively small; bursal canal presents distally two successive enlargements, of which the distal one, opening into the roof of the common antrum, is somewhat glandular.

*Differential diagnosis*.—*S. alabamensis* is distinguished from other species of the genus by the excessive glandularity of the penis papilla and wall of the common antrum.

*Locality*.—Old Saltee Cave, Limrock, Alabama, March 16, 1931.

*Type*.—One whole mount, U.S.N.M., no. 20639; cotype, one set of sagittal serial sections (2 slides), U.S.N.M., no. 20639.

### *Sphalloplana virginiana*, n. sp.

Figs. 4, 5

*Material*.—Many specimens sent by Dr. J. A. Fowler.

*Form*.—Slender, of moderate size, preserved specimens to 12 mm. in length, probably longer in life, anterior end bluntly rounded provided in the center with a weak adhesive organ, margin except anterior end provided with a band of unusually long rhabdites (Fig. 4).

*Color*.—White.

*Eyes*.—Lacking.

*Adhesive organ*.—This consists of the usual irregular depression lined with the outlets of eosinophilous gland cells. From the inner end of the depres-

sion a small band of muscle fibers constituting a retractor muscle proceeds dorsally and joins the dorsal subepidermal musculature.

*Reproductive system.*—Testes ventral, limited to prepharyngeal region. Sperm ducts form usual expanded spermiducal vesicles as they approach the copulatory apparatus; they enter separately the ejaculatory duct (Fig. 5). Penis papilla of moderate size, rounded, not very muscular with slightly developed bulb. Ejaculatory duct a wide canal that has the peculiarity of opening on the ventral surface of the penis papilla (Fig. 5) and is hence asymmetrical located in the papilla. Papilla lies in male antrum into the roof of which opens the common ovovitelline duct accompanied by eosinophilous glands. Copulatory bursa relatively small, lying above penis bulb; bursal canal courses above male antrum and, widening slightly, opens into rear part of common genital antrum. All parts are weakly muscular; muscle fibers are best developed in the wall of the antrum. There is also a general lack of glandular elements in connection with the copulatory apparatus.

*Differential diagnosis.*—The outstanding characteristic of this species is the asymmetrical position of the ejaculatory duct, which opens ventrally at the base of the papilla instead of running through the center of the papilla to its tip as is usual in triclads. To insure that this unusual feature was not accidental, a second specimen was sectioned and showed the same condition.

*Locality.*—Pool in Showhalter's Cave near Lexington, Va., Oct. 30, 1943. A single specimen taken in another cave five miles from Showhalter's Cave was so twisted and distorted that it could not be identified with certainty.

*Type.*—One whole mount, A.M.N.H., no. 314. Cotype, one set of sagittal serial sections (5 slides), A.M.N.H., nos. 315-319.

*Sphalloplana kansensis*, n. sp.

Fig. 6

*Material.*—One specimen sent by Hubricht.

*Form.*—Large, broad, thin, 20 mm. long, anterior end truncate with a conspicuous adhesive organ; marginal rhabdites only a little larger than elsewhere. As there are no distinctive external features, it was thought necessary to illustrate the specimen which has been sectioned.

*Color.*—White.

*Eyes.*—Lacking.

*Adhesive organ.*—Similar to that of *Sphalloplana percoeca*; consists of an irregular depression lined by the outlets of eosinophilous glands; a moderate musculature is attached to the internal surface of the organ.

*Reproductive system.*—Testes dorsal, limited to the prepharyngeal region. Terminal parts of sperm ducts enlarged to form spermiducal vesicles enter separately ejaculatory duct which ascends dorsally, then turns posteriorly and after a short sinuous course becomes straight and passes along the center of the

low rounded penis papilla (Fig. 6). Penis bulb only slightly developed; penis papilla weakly muscular. Male antrum elongated, passing obliquely backwards, lined by a very tall epithelium. Copulatory bursa large, oval, lined by very tall epithelium ventrally, short dorsally; has very long slender bursal canal, passing posteriorly above penis, then turning ventrally and widening greatly to open into antrum. Common antrum is thus small, dividing at once into bursal canal and male antrum. Very large and long common ovovitelline duct, after receiving the two ovovitelline ducts curves posteriorly and ventrally to enter roof of male antrum near opening of latter into common antrum. Usual eosinophilous cement glands accompany ovovitelline ducts and also open into rear wall of common duct. A peculiarity of this species not found in any other planarian is the attachment of irregular blind epithelial outgrowths to the wall of the common antrum.

*Differential diagnosis.*—This species differs from other species of *Sphalloplana* in the very long bursal canal, very large common ovovitelline duct, and epithelial evaginations of the common genital antrum.

*Locality.*—Purity Springs, near Augusta, Butte County, Kansas, May 18, 1942. Although taken in a spring, this species is undoubtedly a cave planarian for it lacks eyes and has the typical aspect of other Kenkiidae.

*Type.*—One set of sections (3 slides), A.M.N.H., nos. 311-313.

Genus *SPEOPHILA* Hyman 1937

*Speophila hubrichti*, n. sp.

Figs. 7, 8

*Material.*—Many specimens sent by Dr. Leslie Hubricht.

*Form.*—Large, broad, to 17 mm. long preserved, evidently longer in life; anterior end broadly rounded with a central conspicuous adhesive organ; body tapers posteriorly to bluntly pointed end; margin with usual band of large rhabdites (Fig. 7).

*Color.*—White.

*Eyes.*—Lacking.

*Adhesive organ.*—Consists of a deep pit with irregularly folded walls that take an intense eosin stain; the pit is surrounded by a halo of eosinophilous glands. The rear end of the pit is provided with a complex musculature.

*Nervous system.*—The nervous system appears to lack definite cerebral ganglia but the ventral cords in the proximity of the inner end of the adhesive organ break up into a complicated network which supplies the adhesive organ and the anterior margins. This form of nervous system seems to be the rule with Kenkiidae having a highly developed adhesive organ.

*Reproductive system.*—Testes dorsal, limited to the prepharyngeal region.

Sperm ducts, after usual expansion to form spermiducal vesicles proceed to penis bulb where after a very short narrowing they enter separately a narrow ejaculatory duct. This traverses the penis bulb, then widens into a broad canal proceeding to penis tip. Penis very large, consisting of muscular bulb and long penis papilla with wide lumen (Fig. 7). Copulatory bursa very large, oval; narrow bursal canal runs caudad above penis bulb, then widens greatly as it curves ventrally to enter antrum. Common antrum thus very small, dividing at once into above large distal part of the bursal canal and the elongated male antrum. Expanded part of bursal canal runs asymmetrically to right side of male antrum. Antrum and distal expanded part of bursal canal lined by tall epithelium, underlain by considerable thickness of muscle fibers. Outer wall of penis papilla has dense muscular layer under the epithelium. Ovovitelline ducts accompanied by usual eosinophilous cement glands approach rear part of male antrum, and unite to common duct that enters roof of male antrum near entrance of latter into common antrum.

*Differential diagnosis.*—*S. hubrichti* differs from other species of *Speophila* in the very large penis with its elongated papilla. The distal expansion of the bursal canal is also seen in *S. buchanani*.

*Locality.*—Taken by Hubricht in Morrison's Cave, near Burksville, Monroe County, Illinois, in spring near Kimmiswich and spring near Selma, Jefferson County, Missouri, all during June, 1937, and most abundantly in Kohn's Cave near Ste. Genevieve, Missouri, Sept. 13, 1941.

*Type.*—One whole mount, A.M.N.H., no. 320; cotype, one set of sagittal sections of copulatory apparatus (4 slides), A.M.N.H., nos. 321-324.

Family DENDROCOELIDAE

Genus PROCOTYLA Leidy 1857

PROCOTYLA TYPHLOPS Kenk 1935

There was received for identification from the U.S. National Museum a single specimen of a triclad taken in the burrow of a crayfish, *Procambarus rathbunae* (Hobbs), near Crestview, Florida, by H. H. Hobbs, Oct. 17, 1941. The animal was sectioned and the copulatory apparatus was found to agree in all particulars with Kenk's description of *Procotyla typhlops*. The specimen, however, differed from Kenk's material in that it had a pair of small eyes. That these are true eyes was verified on the sections. Hence it appears that this species is not necessarily blind. The sections have been deposited in the U.S.N.M.

GENERAL REMARKS

The present contribution makes a total of eleven species of cave planarians known for the United States, if *Sphalloplana kansensis*, as yet found only in a spring, be included. Present findings indicate that every sizable cave or group of caves in a given region has its own species. Evidently residence in a cave constitutes a form of geographical isolation leading to speciation. It may be of interest to list here the known species with their localities.

## Family PLANARIIDAE

- Phagocata subterranea* Hyman, 1937 ..... Indiana

## Family KENKIIDAE

- Sphalloplana percoeca* (Packard) 1880 ..... Kentucky  
*Sphalloplana mohri* Hyman, 1939 ..... Texas  
*Sphalloplana alabamensis* ..... Alabama  
*Sphalloplana virginiana* ..... Virginia  
*Sphalloplana kansensis* ..... Kansas  
*Speophila pricei* Hyman, 1937 ..... Pennsylvania  
*Speophila buchanani* Hyman, 1937 ..... Kentucky  
*Speophila hubrichti* ..... Illinois, Missouri  
*Kenkia rhynchida* Hyman, 1937 ..... Oregon

## Family DENDROCOELIDAE

- Sorocelis americana* Hyman, 1939 ..... Oklahoma

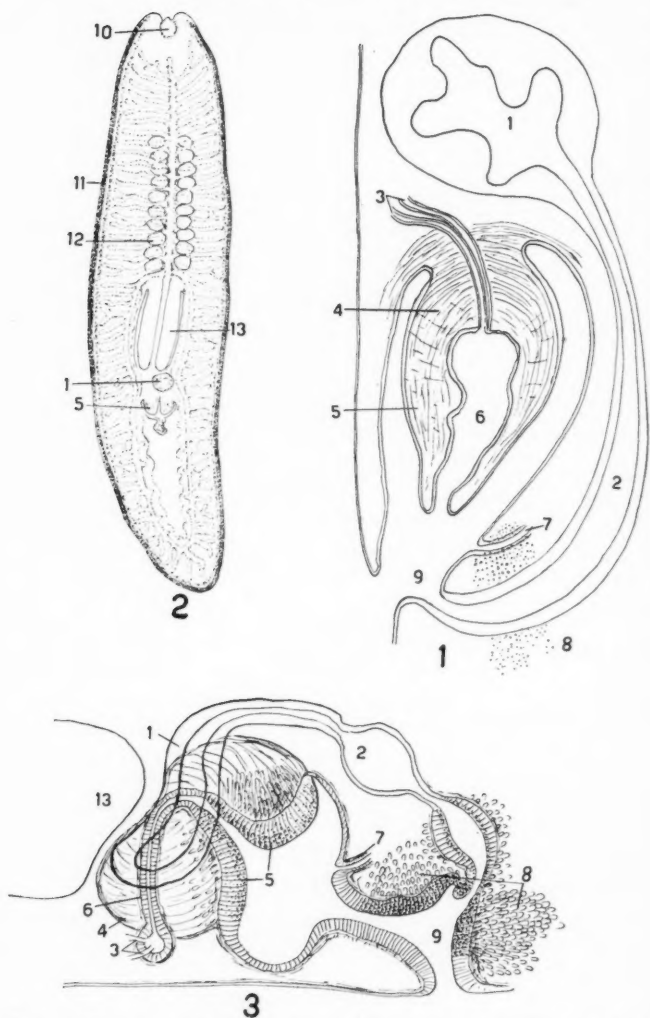
Most of the species belong to the genera *Sphalloplana* and *Speophila*. The latter genus is distinguished by the greater complexity of the adhesive organ. However, it is probable that all gradations in the development of the adhesive organ exist among the Kenkiidae and hence that eventually it will be impossible to draw any definite line between these two genera. I therefore anticipate that when our cavernicolous planarians are sufficiently known, *Speophila* will become a synonym of *Sphalloplana*.

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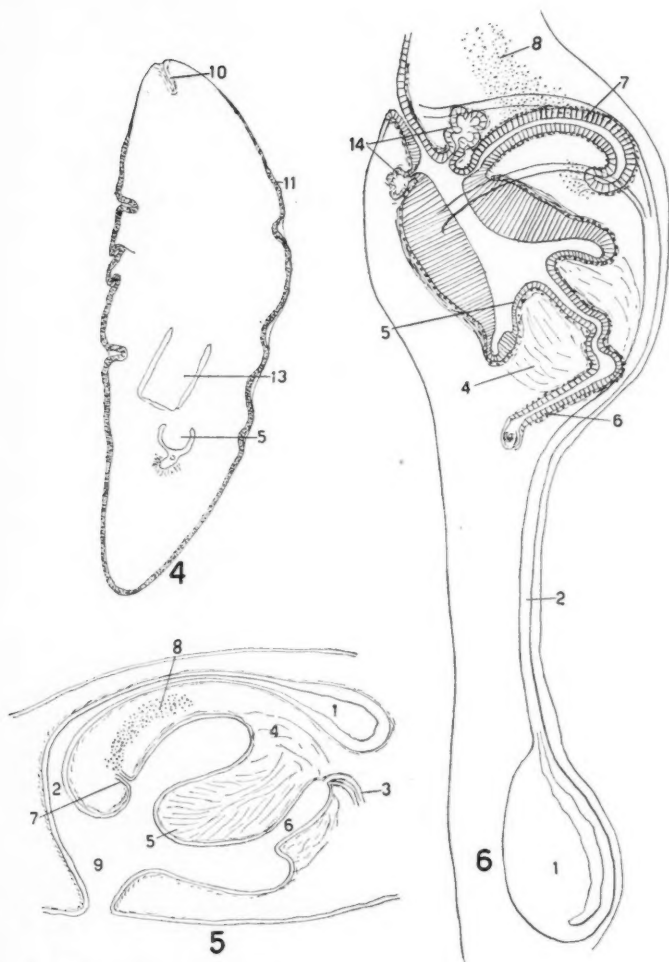
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FOR ALL FIGURES: 1, Copulatory bursa; 2, bursal canal; 3, sperm ducts; 4, penis bulb; 5, penis papilla; 6, ejaculatory duct; 7, common ovovitelline duct; 8, cement glands; 9, common genital antrum; 10, adhesive organ; 11, marginal band of large rhabdites; 12, testes; 13, pharynx; 14, epithelial evaginations of antrum.

Fig. 1. Sagittal section of the copulatory apparatus of *Phagocata gracilis monopharyngea*. Fig. 2. *Sphalloplana alabamensis*. Fig. 3. Sagittal section of the copulatory apparatus of *Sphalloplana alabamensis*.

Fig. 4. *Sphalloplana virginiana*.Fig. 5. Sagittal section of the copulatory apparatus of *Sphalloplana virginiana*.Fig. 6. Sagittal section of the copulatory apparatus of *Sphalloplana kansensis*.

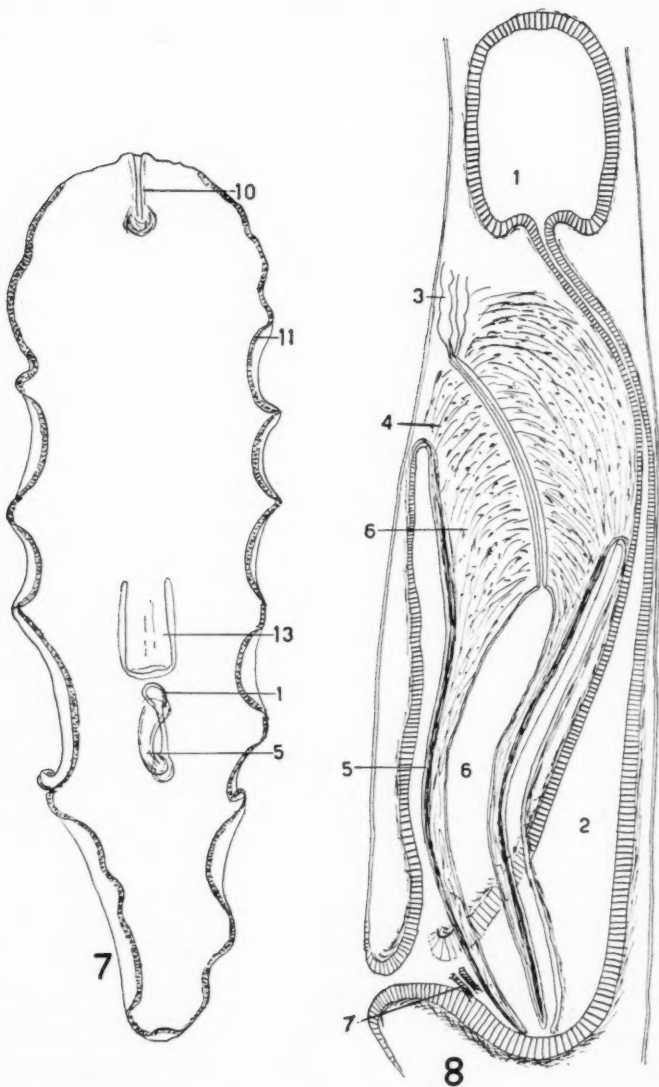


Fig. 7. *Speophila hubrichti*.

Fig. 8. Sagittal section of the copulatory apparatus of *Speophila hubrichti*.

## The Nematode Genus *Abbreviata* (Travassos, 1920) Schulz, 1927<sup>1</sup>

Banner Bill Morgan<sup>2</sup>

The genus *Abbreviata*<sup>3</sup> was first proposed by Travassos (1920) to accommodate certain species of physalopteroid nematodes with dissimilar spicules, 2 uteri, and 4 pairs of stalked or pedunculated papillae. Schulz (1927) emended this generic diagnosis to include species which carry 1 externolateral tooth, 1 internolateral tooth and 2 double submedian teeth on each pseudolabium. Usually the entire margin of pseudolabia is dentated. *Physaloptera abbreviata* Rudolphi, 1819, from *Lacerta margaritacea* (lizard) Spain—was made the type species.

Schulz (1927) placed 23 species in this genus. Since, 1927, several more species have been placed in *Abbreviata*. No revised list has been published and a list published in English has not been available prior to this paper. The purpose of this paper is to give a revised list of the species of *Physaloptera* now placed in *Abbreviata*, to present a world host list, and to supplement it by new observations.

Since Schulz's work was published in Russian and is not readily accessible, a generic diagnosis is given. This genus is found chiefly in the Reptilia, less common in Mammalia (Rodentia, Carnivora, Primata, and Artiodactyla) and Amphibia. The host-parasite list has been arranged by orders and families to facilitate a comprehensive view of host-parasite relationships. The list is also arranged by the number and mode of origin of the uteri in the female worm, an important taxonomic character [2-A (2 uteri with common trunk), 4-D (4 uteri with common trunk), 4-E (4 uteri with bifurcation of common trunk), 5-15 G (5-15 uteri with common trunk), and 9-13 H (9-13 uteri without common trunk)].

At the present time only 3 species of *Abbreviata* have been reported from North America; namely *A. varani*, *A. ranae*, and *A. terrapenis*. *Abbreviata varani* was originally described from a monitor (*Varanus bengalensis*) from Ceylon. Since that time this parasite has been studied by several workers: Shipley (1900), Linstow (1908), Leiper (1908), Seurat (1914), Ortlepp (1922), and Hsu and Hoeppli (1931). The first North American record of *A. varani* was made from material sent to the U.S. National Museum from the stomach of the Eastern swift (*Sceloporus undulatus*) from Maryland. The

<sup>1</sup> This investigation was aided by a grant from the Wisconsin Alumni Research Foundation.

<sup>2</sup> Assistant Professor and Parasitologist, Department of Veterinary Science, University of Wisconsin.

<sup>3</sup> Travassos originally spelled the genus *Abreviata*. The correct usage should conform with the earlier spelling of Rudolphi's species, *Physaloptera abbreviata*.

writer examined 23 Eastern swifts (*S. undulatus*) from Wisconsin, Illinois, and New York and found 2 animals infected with *A. varani*.

*Abbreviata ranae*, a larval form, was described by Walton (1931) from cysts in the stomach and intestine of a bullfrog (*Rana catesbeiana*). Trowbridge and Hefley (1934) reported *A. ranae* from a leopard frog (*Rana sphenoccephala*) from Oklahoma. Kuntz (1940) found this parasite in the stomach of the toad (*Bufo w. woodhousii*) from Oklahoma. The writer found 3 out of 90 bullfrogs (*R. catesbeiana*) from Louisiana infected with *A. ranae* and 2 out of 539 *Rana pipiens* (leopard frog) from Wisconsin and Illinois infected. The immature *Physaloptera* sp. reported by Brandt (1936), Rankin (1937) and Reiber, Byrd, and Parker (1940) from frogs and salamanders may be *Abbreviata*. As all of the *Abbreviata* reported from frogs are immature, Amphibia may be accidental hosts.

*Abbreviata terrapenis* (Hill, 1941) was described from specimens removed from the stomach of the Western box turtle (*Terrapene ornata*) from Oklahoma. The writer has found immature *Abbreviata* from *Chrysemys marginata* (Western painted turtle), *Chelydra serpentina* (snapping turtle), and *Emys blandingii* (Blanding's turtle) all from Wisconsin and representing new host records.

ABBREVIATA (Travassos, 1920). Generic diagnosis, emend. Schulz, 1927. Synonyms.—*Abreviata* Travassos, 1920; *Leptosoma* Travassos, 1920.

Oral opening surrounded by 2 large single-lobed lateral pseudolabia, each bearing 1 externolateral tooth, 1 internolateral tooth, 2 double submedian teeth; 2 external papillae and 1 amphid. Usually entire margin of pseudolabia dentate. *Male*: tail with broad, lateral alae which connect across the ventral surface in front of the cloaca. Usually 4 pairs of pedunculated or stalked papillae supporting lateral alae, usually 2 pairs pre-cloacal and 2 pairs post cloacal. Number of sessile, ventral, genital papillae variable; usually 3 pre-cloacal, 2 pairs surrounding cloaca, and 3, 4, or 5 pairs further down on tail. Ventral surface of tail also covered with longitudinal or broken rows of tubercles. Spicules equal, subequal, but generally unequal. *Female*: vulva in first half of body, usually in anterior third; uterus with 2 (didelphys), 4 (tetradelphys), or more than 4 (polydelphys) branches. Eggs usually oval, smooth, thick-shelled, containing embryos when deposited. *Habitat*: Parasites of the stomach of Amphibia, chiefly Reptilia, and Mammalia; more rarely in the mouth, esophagus, intestine, and eye-socket of the above hosts.

#### PARASITE-HOST LIST OF ABBREVIATA

##### 2-A UTERI

1. *Abbreviata gracilis* (Ortlepp, 1922). LACERTILIA. "Lizard" Ortlepp, 1922; Uganda.

2. *A. leptosoma* (Gervais, 1848). LACERTILIA. (Varanidae) *Varanus griseus* (desert monitor) Seurat, 1917; Algeria. (Agamidae) *Uromastix acanthinurus* (spiny-tailed lizard), *U. a. nigriventris* (spiny-tailed lizard) Ibid.

##### 4-D UTERI

3. *A. abbreviata* (Rudolphi, 1819). LACERTILIA. (Lacertidae) *Lacerta margaritacea* (lizard) Rudolphi, 1819; Spain. *L. ocellata* (eye lizard), *L. viridis* (green lizard)

Diesing, 1851; Spain. Seuiat, 1914; 1917; Algeria. (Agamidae) *Phrynocephalus helioscopus* (sand lizard) Stossich, 1889; Turkestan. *Agama* sp. (Agama lizard) Skrijabin, 1916; British East Africa. (Anguidae) *Pseudopus palasii* = *Ophisaurus opodus* (glass-snake) Stossich, 1889; Turkestan. OPHIDIA (Colubridae) *Tropidonotus hydrus* (water snake) Stossich, 1889; Turkestan.

4. *A. africana* (Monnig, 1923). RODENTIA (Muridae) *Arvicanthis pumilis* (striped mouse) *Mus coucha* (white-nosed rat), *M. pretoria* (Pretoria rat). (Octodontidae) *Thryonomys swindernienus* (cane rat). Monnig, 1923; South Africa. (Sciuridae) *Paraxerus cepapi* (gray-footed squirrel) Ibid.

5. *A. amaniensis* (Sandground, 1928). LACERTILIA. (Agamidae) *Agama mossambica* (dragon lizard) Sandground, 1928; Africa.

6. *A. antarctica* (Linstow, 1899). Syn. *Physaloptera alba* Stossich, 1902. OPHIDIA. (Elapidae) *Acanthopis antarctica* (death adder) Linstow, 1899; Australia. (Boidae) *Python spilotes* (diamond snake or python) Ortlepp, 1922; Australia. LACERTILIA. (Scincidae) *Cyclodus* = *Tiliqua occipitalis* (broad-banded blue-tongued skink) Linstow, 1899; Australia. *Cyclodus boddaertii* = *Tiliqua scincoides* (Northern blue-tongued skink) Stossich, 1902; Holland? probably Australia. (Varanidae) *Varanus varius* (lace monitor) Ortlepp, 1922; Australia. Johnson and Mawson, 1941; Australia. Canavan, 1931; Australia.

7. *A. bancrofti* (Irwin-Smith, 1922). Syn. *Physaloptera natricus* Kreis, 1940; *P. physignathi* Baylis, 1924. LACERTILIA. (Geckonidae) *Symnodactylus platurus* (gecko) Irwin-Smith, 1922; Australia. (Agamidae) *Physignathus lesurii* (water lizard) Baylis, 1924; New Zealand. OPHIDIA. (Colubridae) *Natrix hypomelas* (water snake) Kreis, 1940; location not given.

8. *A. caucasica* (Linstow, 1902). Syn. *Physaloptera mordens* Leiper, 1908. PRIMATA. (Hominidae) *Homo sapiens* (man) Linstow, 1902; Caucasus. Leiper, 1908, 1911, 1913; Uganda. Ortlepp, 1922; Africa. Gedoelst, 1911; Africa. (Lasiopygidae) *Papio hamadryas* (Arabian baboon) Canavan, 1929; Arabia, North East Africa. Feng, 1931; location not given. *Macaca sylvana* (barbara ape) McClure, 1930; location not given. "Monkeys" Ortlepp, 1922; Africa.

9. *A. heterocephala* (Kreis, 1940). LACERTILIA. (Agamidae) *Gonyocephalus modestus* (dragon lizard) Kreis, 1940; location not given.

10. *A. leidy* (Walton, 1927). LACERTILIA. (Varanidae) *Varanus varius* (lace monitor) Walton, 1927; location not given.

11. *A. leiperi* (Skrjabin, 1924). RODENTIA. (Sciuridae) *Spermophilopsis leptodactylus* (ground squirrel) Skrijabin, 1924; Russia.

12. *A. oligopapillata* (Kreis, 1940). LACERTILIA. (Scincidae) *Sphenomorphus jobiensis* (skink) Kreis, 1940; location not given.

13. *A. ortleppi* (Sandground, 1928). LACERTILIA. (Chamaeleontidae) *Chamaeleon dilepis* (Chamaeleon) Sandground, 1928; Africa.

14. *A. pallaryi* (Seurat, 1917) LACERTILIA. (Agamidae) *Agama bibroni* (lizard) Seurat, 1917; Morocco.

15. *A. polydentata* (Walton, 1932) LACERTILIA. (Geckonidae) *Hemidactylus mabouia* (gecko) Walton, 1932; British East Africa.

16. *A. terrapenis* (Hill, 1941) CHELONIA. (Testudinidae) *Terrapene ornata* (Western box turtle) Hill, 1941; Oklahoma.

17. *A. vandenbrandeni* (Gedoelst, 1924) CARNIVORA. (Felidae) *Felis* sp. (wildcat) Gedoelst, 1924; Belgian Congo.

18. *A. varani* (Parona, 1889) Syn. *Physaloptera quadrovaria* Leiper, 1908. LACERTILIA. (Varanidae) *Varanus bengalensis* (Bengal monitor) Parona, 1889; Ceylon. Ortlepp, 1922; Ceylon. *V. indicus* (Indian monitor) Ortlepp, 1922; India. Shipley, 1900; Western Pacific Isles. *V. niloticus* (Nile monitor) Leiper, 1908; Sudan. OPHIDIA. (Colubridae) *Zaocys dhumnades* (rat snake) Hsu and Hoepli, 1931; China.

## 4-E UTERI

19. *A. achari* (Mirza, 1935). LACERTILIA. (Agamidae) *Calotes versicolor* (blood-sucker or changeable lizard) Mirza, 1935; India.

20. *A. paradoxa* (Linstow, 1908) Syn. *Physaloptera affinis* Geddoelst, 1916. LACERTILIA. (Varanidae) *Varanus albigularis* (white-throated monitor) Linstow, 1908; South Africa. Ortlepp, 1922; South Africa. *Varanus griseus* (gray monitor) Seurat, 1914; Algeria. OPHIDIA. (Viperidae) *Cerastes cornutus* (horned viper) Seurat, 1914; Algeria. (Colubridae) *Psammophis sibilans* (whip snake) Geddoelst, 1916; Belgian Congo. Ortlepp, 1922; "Snakes" Sudan. Ortlepp, 1922; Sudan, Nigeria.

21. *A. tasmania* (Ortlepp, 1937) LACERTILIA. (Chamaeleontidae) *Chamaeleon macrolepis* (Chamaeleon). Ortlepp, 1937; Rhodesia.

## 5-15 G UTERI

22. *A. capensis* (Ortlepp, 1922). RODENTIA. (Sciuridae) *Xerus setosus* (Cape ground squirrel) Ortlepp, 1922; South Africa.

23. *A. musculi* (Thwaite, 1927) RODENTIA. (Muridae). "domestic mouse" Thwaite, 1927; Ceylon.

24. *A. poecilometra* Sandground, 1936. PRIMATA. (Callitrichidae) *Cerocopithecus mitis* (monkey) Sandground, 1936; East Africa.

25. *A. joyeuxia* (Gendre, 1928). ARTIODACTYLA (Suidae) *Phacochoerus africanus* (wart hog) Gendre, 1928; Africa.

## 9-13 H UTERI

26. *A. multipapillata* (Kreis, 1940). PRIMATA. (Lasiopygidae) *Papio hamadryas* (Arabian baboon) Kreis, 1940; location not given.

## LARVAL FORM

27. *A. ranae* (Walton, 1931). ANURA. (Ranidae) *Rana catesbeiana* (bullfrog) Walton, 1931; Indiana. This paper, Louisiana. *R. pipiens* (leopard frog), this paper, Wisconsin, Illinois. *R. sphenoccephala* (leopard frog). Trobridge and Hefley, 1934; Oklahoma. (Bufonidae) *Bufo w. woodhousii* (toad) Kuntz, 1940; Oklahoma.

*Abbreviata numidica* (Seurat, 1917) from *Dipodillus campestris* (pigmy gerbil rat) Africa. *A. britanica* (Skrjabin, 1916) from *Agama* sp. (lizard) British East Africa. *A. elegantissima* (Stossich, 1902) from *Ratel* = *Mellivora capensis* (honey-badger) Africa, and *A. clelandi* (Irwin-Smith, 1922) from *Varanus varius* (lace monitor) Australia, must await further descriptions as males are unknown. *A. leidy* (Walton, 1927) may be a synonym of *A. clelandi*. *Abbreviata dentata* (Linstow, 1883) from *Agama sanguinolenta* (lizard), *Vipera berus* (viper), and *Phrynocephalus auritus* (sand lizard); *A. spiralis* (Schneider, 1866) from *Amphisbaena* sp. (worm lizard) Brazil; *A. sonsonoi* (Linstow, 1895) from *Agama mutabilis* (Egyptian lizard) Pisa; *A. aloisi-sabaudiae* (Parona, 1907) from *Agama atricollis* (black-necked lizard) Africa; and *A. gemina* (Linstow, 1899) from *Felis domestica* (cat) Egypt; all lack complete descriptions and cannot be classified until restudied. No doubt many synonyms still exist in this genus. Of the 27 species listed, 17 are parasites of Reptilia, 4 of Rodentia, 3 of Primata, and one each for Carnivora, Artiodactyla, and Anura. The majority of species are found in Africa, the remainder in Europe, Asia, Australia, and North America.

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## Two New Chitons from the Gulf of California

S. Stillman Berry

This is the first of a series of sporadic short papers on the chiton fauna of West American tropical waters. For purposes of convenience of treatment I include therewith the whole of the Gulf of California despite the fact that certain quite distinct traces of Temperate influence occur in its upper reaches. As it will be desirable to refer to them shortly in other connections, two species from the Gulf thought to be undescribed are given an established status in the following pages.

It is a pleasure to acknowledge my indebtedness to the various collectors mentioned for their very generous gifts of the material required for the study.

### *Chaetopleura (Pallochiton) euryplax*, n. spec.

**Description.**—Chiton of medium size, elongate-oval in outline, well elevated, the ridge obtusely angulated while almost straightly sloping on the sides. Entire surface of shell minutely granulose and ornamented with further sculptural detail as itemized below.

*Anterior valve* crescentic, obscurely but copiously radially furrowed, and bearing many small scattered rounded grains or tubercles, which only occasionally exhibit some small trace of radial alignment.

*Intermediate valves* somewhat mucronate when uneroded, but the beak often much worn down in the adult. Central areas bearing on each side about 13 to 16 finely and quite irregularly beaded, obliquely diverging lirae, which tend to fade out laterally, while on the jugum they are finer, more crowded, and the beading often tends toward obsolescence. Jugal tract marked principally by the fineness of the lirae and a certain distinguishable difference in their trend as one passes to the pleural tracts. Lateral areas elevated, especially on valve ii, where there is a marked slope downward into the somewhat sunken pleural tracts, and ornamented with scattered granules like those of valve i.

*Posterior valve* depressed, obtusely V-shaped; mucro blunt and very posterior in position, the terminal slope thus much reduced and bent over bluntly into the eaves with most of its sculpture undeveloped or obsolescent, although there persist a few rounded granulations similar to those seen on valve i, and several of the growth-lines are strengthened so powerfully at times as to produce a somewhat laminated appearance from the rear. Central area sculptured in essentially similar fashion to those of the intermediate valves, but in some cases more crudely, in others more obsoletely than described above, there being about 9 of the bearded lirae on each side.

*Interior of valves* grayish white, thickened across the middle, and heavily

stained with brown in the deeper portions. Anterior valve with a heavy, abruptly edged, finely but strongly longitudinally striate plate filling the posterior sinus; insertion plates long and strong, narrowly beveled at the edge, their outer sides finely irregularly striate, the striae only very weakly crenulating the edge; slits separating the teeth cut through less than half-way to the base, being represented the rest of the way on the outer side by deep, sharply cut troughs; interior strongly calloused, obscuring the usual radial series of pores which are hardly or not at all in evidence. Intermediate valves with insertion plates truncate posteriorly, making them narrowly, sharply, and very obliquely triangular in form rather than squared, the outward striation much weaker than on valve *i*; sutural laminae large, strongly projecting, arcuate, somewhat sinuous, truncate at the angular, notch-like lateral slit; sinus squared, the articulamentum notched at the sides and abruptly beveled off beneath the finely crenulated margin of the tegmentum. Posterior valve sharply furrowed out behind the very massive sutural laminae, with a strong buttress-like thickening behind that; posterior plates rude, massive, short, directed slightly forward, the lateral ones more obliquely and strongly so; grooving of outer surfaces of teeth shallow and crude. Slit formula 8 to 10, 1-1, 7 to 8.

Girdle leathery and dorsally scaleless to the naked eye, but under high magnification appearing exceedingly finely and closely pilose, with a scattering of small, transparent, sword-shaped spinules.

Measurements (of largest example).—Max. long., 31.0; max. lat., 16.2; long. shell only, 30.0; lat. tegmentum valve *iv*, 12.4; alt. 6.3 mm.

Holotype.—Cat. No. 8943 Berry Collection.

Paratypes.—Cat. No. 8564 Berry Collection; others to be deposited in the collections of the National Museum of Mexico, the United States National Museum, San Diego Museum of Natural History, and the private collection of Mr. E. C. Huffman of Pasadena, California.

Type-locality.—Bahia de Adair, Sonora, Mexico; taken alive under stones at low tide, E. C. Huffman, 1937.

Remarks.—This fine species is so similar to the well-known *C. lanuginosus* ("Carpenter" Dall 1879:297, pl. 3, fig. 21; Pilsbry 1893:257, pl. 56, figs. 1-11) that the two must certainly share a not too distant common origin, although critical inspection shows them to differ in one way or another at almost every point. From the standpoint of the systematist the more trenchant characters differentiating *C. euryplax* are 1) the much longer and proportionately less deeply slitted insertion plates, particularly those of valve *i*; 2) the convex and more pointed tail valve, with its narrower, squarer sinus and wider, fewer, more oblique and much less forward-projecting teeth; 3) the generally sparse sculpture, especially the much less numerous lirae of the pleural regions.

The specific name is derived from the Gr. *εὐρύς*, broad, spacious, + *πλάξ* a flat, broad object, such as a tablet, and refers to the remarkably produced insertion plates of the anterior valve.

*Stenoplax histrio*, n. spec.

Description.—Animal small, elongate. Shell moderately heavy, rounded to subcarinate on the ridge, the side-slopes weakly to moderately convex; valves distinctly beaked in the young or when not eroded. General surface of tegmentum very finely punctate; not glossy but with a luster somewhat as though lightly annealed or varnished.

*Anterior valve* evenly crescentic, the tegmental surface nearly smooth toward the apex but broken on the slopes into low, crowded, and very irregularly concentric rugae, which are usually interrupted by a system of irregular shallow radiating grooves, so variably that on some examples the concentric, on others the radial sculpturing may appear dominant. A few lines of growth may often be more strongly emphasized than others. Posterior margin quite distinctly dentated at the sides by projections from the rugae.

*Intermediate valves* with lateral areas distinctly raised and sculptured in somewhat similar fashion to the head valve save that the 5 to 7 radial ridges are a little more strongly emphasized; central areas very closely and minutely lirate, the riblets heaviest on the slopes, very fine and close on the ridge, the beaks often worn quite smooth, especially that of the very large second valve; on examples showing especial strength of the concentric rugation on the lateral areas, the riblets of the central areas may also tend to break up irregularly; posterior margin with 10 to 12 coarse denticles on each side, smoothing out toward the beak.

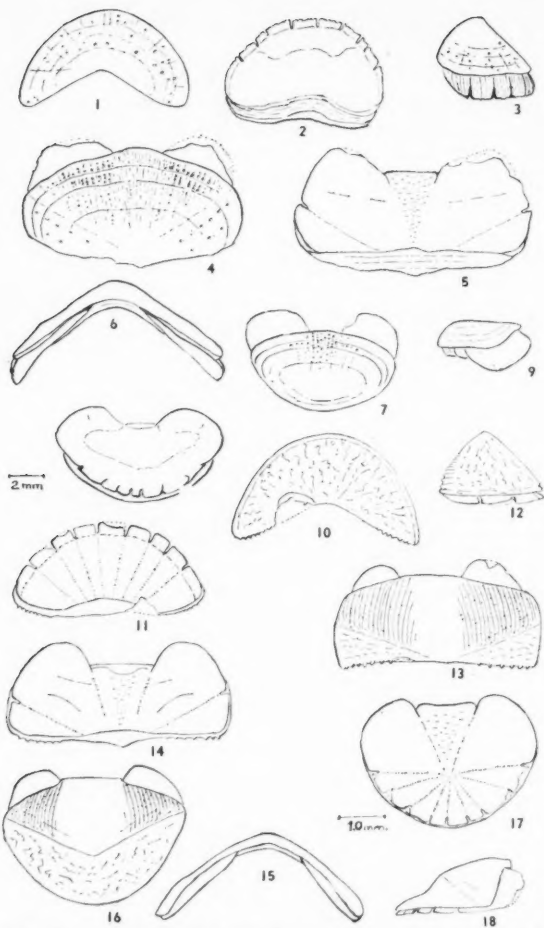
*Posterior valve* large, the mucro conspicuous, placed behind the middle; high and arcuate in front, the posterior slope strongly concave; region behind mucro with sculpture rather weaker than that of the lateral areas and head valve but otherwise nearly similar; region in front sculptured essentially like the central areas of the intermediate valves.

*Interior* with translucent articulamentum, that of the intermediate valves strongly thickened across the middle. Sutural laminae thin, low, wide, gently sloping outward from near the wide untoothed sinus from which they are separated by small notches, especially conspicuous in the tail-valve. Insertion teeth sharp and clean-cut. Eaves thin, projecting, but shorter than the teeth. Slit formula 9 to 10, 1-1, 7 to 10.

*Girdle* rather narrow, coveed dorsally by a heavy imbricating armature of thick smooth scales, large in the group for the size of the shell.

*Color* of outer surface of shell 1) brownish cream, the girdle maculated brown and cream, or with a few blackish spots toward the ends; 2) cream, brownish gray or dove color, varyingly maculated, especially toward the jugum, with spots and flames of black, cream, tan, burnt orange, light blue, and brown, the cream spots often edged black at the lower side to give the appearance of eye-like oculations. Interior little tinted except as the tegmental color may reflect through.

Measurements (of holotype).—Max. long., 13.2; max. lat., 6.8; long. shell only, 12.3; lat. tegmentum valve iv, 5.5 alt. 3.0 mm.



Figs. 1-9. *Chaetopleura (Pallochiton) euryplax* n.sp. (All figures of this species drawn to same scale). 1. Dorsal view of anterior valve of holotype. 2. Interior view of same; a large pathological lesion near the summit of the valve is not shown. 3. Right profile of same. 4. Dorsal view of valve v of holotype. 5. Interior view of same. 6. Anterior elevation of same. 7. Dorsal view of posterior valve of holotype. 8. Interior view of same. 9. Right profile of same.

Figs. 10-18. *Stenoplax histrio* n. sp. (All figures of this species drawn to same scale). 10. Dorsal view of anterior valve of holotype. 11. Interior view of same. 12. Right profile of same. 13. Dorsal view of valve v of holotype. 14. Interior view of same. 15. Anterior elevation of same. 16. Dorsal view of posterior valve of holotype. 17. Interior view of same. 18. Right profile of same.

(All figures were drawn with aid of camera lucida. The details of the rather complicated tegmental sculpturing are merely indicated in the drawings.)

Holotype.—No. 8040 in Type Series of California Academy of Sciences.

Paratypes.—Cat. No. 7116 Berry Collection; others to be deposited in the collections of the National Museum of Mexico, United States National Museum, and San Diego Museum of Natural History.

Type-Locality.—El Gallo, Mulege, Baja California; Fred M. Reed, 27 Jan. 1929.

Additional Localities.—El Sombrerito, Mulege, Baja California (Fred M. Reed); Concepcion Bay, Baja California (Ricketts and Steinbeck); Guaymas, Sonora (Rev. E. B. Hunter).

Remarks.—This small species is, in its best forms, genuinely a thing of beauty, the only very brilliantly colored *Stenoplax* of our lists. As it seems incredible that it could altogether have escaped the eyes of the many previous collectors in the field, its failure to meet with due notice in the literature must be due to its confusion by students with the young of some of the older species. It is separable at once from juvenile *S. conspicua* ("Carpenter" Dall 1879: 296, pl. 2, fig. 11; Pilsbry 1892:63, pl. 15, figs. 91-96) by its convex head-valve, fewer lateral slits, and the linear sculpturing of the central areas. From young *S. limaciformis* (Sowerby 1832:26) it may be distinguished by the radially sculptured lateral and terminal areas and the much shorter tail valve. It somewhat suggests some forms of *S. floridana* (Pilsbry 1892:58) but the ribs of the central areas are wider, flatter, and have narrower interspaces, and the sutural laminae are conspicuously wider and flatter, while the pebbly scaling of the girdle is likewise characteristic, being heavier than in any of the three species named.

The specific name is the *L. histrio*, actor, and refers to the free painting of the tegmentum.

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# Tanypodinae of Iowa (Diptera)

## I. The Genus *Pentaneura* Philippi (*Tanypus*)

U. A. Hauber

During the past five years the writer, assisted by students, has been collecting and rearing local *Chironomidae* (*Tendipedidae*). The present paper lists eleven Iowa species of the subfamily *Tanypodinae* which belong in the genus *Pentaneura* Philippi (*Tanypus* and *Pelopia* of some older authors are, in part, synonyms of *Pentaneura*). The adults of three of these were described by G. S. Walley from Canada; two of them have not yet, to our knowledge, been reported from the United States. We are describing as new the pupae or pupal casts of these three and the larva of one of them.

### A. GROUP A OF EDWARDS

This group includes those species that have spotted or banded wings and three dark rings on the tibiae. The literature reports only two species from the United States to which Walley added five more from Canada. Since the *Chironomidae* are good travelers Canadian species should be found widely distributed in the United States and our Iowa finds seem to confirm this theory.

The following descriptive key, adapted from Walley, will serve to distinguish the adults of this group in our collection:

- Costa not produced; wings spotted or banded; the fore tibia with three dark rings ..... The *monilis* group
1. Middle dark band of fore tibia near apical end; wing spots confluent into irregular bands; basistyle with a large bulge at base. (Common in Davenport and at Okoboji, June to September) ..... *Pentaneura monilis* (L.)  
Middle band equidistant or nearly so from apical and sub-basal bands ..... 2
  2. Basistyle bulbous at base; wing spots forming three irregular bands as in *monilis*; basal white band of fore tibia about one fourth as broad as sub-basal black band. (Common in Davenport, April to August; breeds in ponds and shallow water) ..... *Pentaneura basalis* (Walley 1925)  
Basistyle not bulbous at base ..... 3
  3. Basal white band of fore tibia about one fourth as broad as sub-basal black band (as in *basalis*); the subapical wing spot between M and Cu<sub>1</sub> is directly posterior to the spot between M and R<sub>4+5</sub>. (Two males from Okoboji, Ia., July and August) ..... *Pentaneura illinoensis* (Malloch)  
Basal white band of fore tibia subequal to sub-basal black band; wing spots not as above ..... 4
  4. Middle dark band of tibia slightly beyond middle of distance between sub-basal and apical bands. The subapical wing spot between M and Cu<sub>1</sub> is nearer to the apex of the wing than the spot between M and R<sub>4+5</sub>; Abdomen mostly greyish white with dirty brown spots. Hypopygium (see Walley's fig. 2, 1928) has a rather long neck piece (the connection

between the 8th segment and the hypopygium) with a lateral notch on each side distally. The middle piece of the hypopygium is squarish and located proximad of the basistyles. (Davenport, April, May, October; Okoboji, June to August. Breeds in shallow ponds).

.....*Pentaneura mallochi* (Walley 1925)

Not as above. The subapical spot between M and  $Cu_1$  is nearer the base of the wing than the spot between M and  $R_{4+5}$ . Pronotum pale, often almost white. There is a sharp notch at the latero-distal angle of the neck piece of the hypopygium (fig. 2) and the middle piece is located on a level with the base of the basistyles. (Davenport, April 16: Clinton County in June. Also reported from Missouri by Adams 1940. Breeds in shallow water.)

.....*Pentaneura pelecensis* (Walley 1926)

A word on wing spots: My observation is that the spots and bands on the wings of this group are due to a combination of causes. The hairs, both macro- and microtrichia may be more crowded in some areas than in others, they may be transparent in one area and dark in others, and there are stained areas in



Fig. 1. *Pentaneura monilis* (L.). Mounted in methacrylate. Photo by transmitted light,  $\times 12$ .

the wing membrane. The more conspicuous effects are produced by denser areas of dark macrotrichia and since these are easily rubbed off in handling, identification from wing spots is often unsatisfactory. By transmitted light the spots do not show unless the wings are immersed in a liquid.

The hypopygia of the five species in our collection are similar, almost identical in the dististyles. The middle piece of the hypopygium (the rather complicated mechanism of spines, spinules and membranes located between the base of the basistyles) varies rather strikingly but it will require a detailed anatomical analysis before it can be used safely in the determination of species. *P. monilis* and *P. basalis* have a more or less pronounced bulge at the base of the basistyle and this distinguishes them from the other species of the group.

The pupae in our collection that belong to this group are all similar to that of *P. monilis* as described by Zavrel and Thienemann 1921 and by Johannsen 1937. The *monilis* pupa, however, is larger (5.6 mm.) and has more brown color than the others. The appended description of three pupae in our collection seem to be new.

#### PENTANEURA BASALIS (Walley)

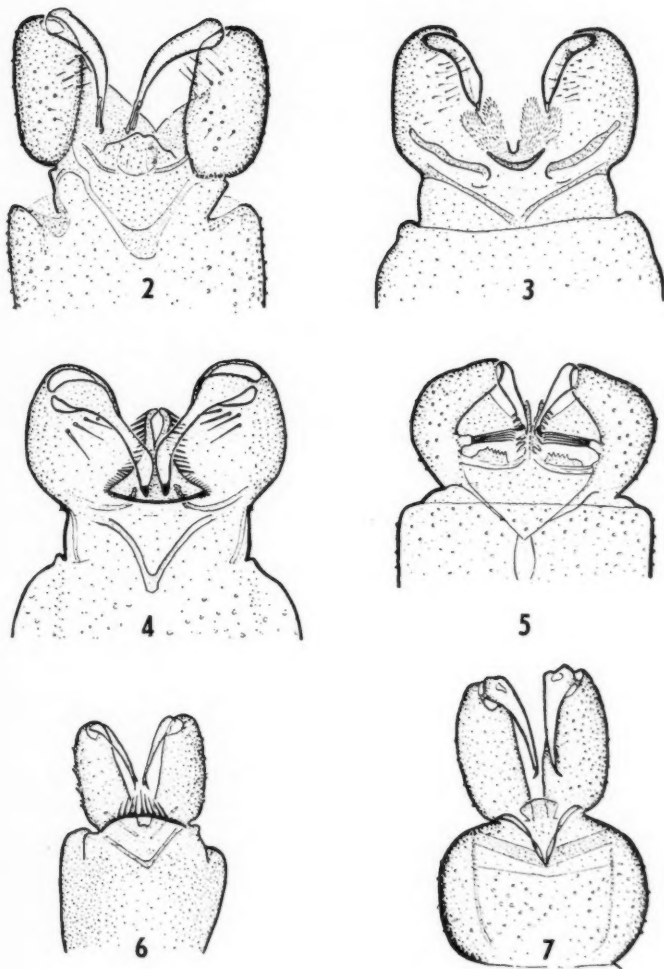
One pupal cast of female (no. 1332). Length 4.8 mm. Similar to the *illinoensis* pupa described briefly by Malloch 1915. The brown areas on abdominal segments 2 to 6 are like those of *P. monilis*. The shagreen is rather coarse and uniform on all segments except the second. The respiratory organ (fig. 11) is .43 mm. long and has a fine hair attached apically which is as long as the organ itself, possibly longer. This hair, while slender and flexible, is quite strong; one can grasp it with a forceps and it holds while one pulls the cast about in the water. Between the respiratory organs there is a transverse row of about twenty cylindrical, blunt spines (fig. 11). In casts this row is broken in two in the middle so that one half of it comes to lie on the side of each respiratory organ. The operculum of the cast (fig. 11) is suborbicular.

#### PENTANEURA MALLOCHI (Walley)

Two pupal casts and one pupa (nos. 350, 1017, 234). Length 4.45 mm. Brown tints very faint. Respiratory organ (fig. 10) about .36 mm. long with a pale projection apically containing a very short respiratory tubule as in *P. monilis*. There are 14 to 16 broad-based, triangular, pointed and slightly curved spinules in the transverse row between the base of the respiratory organs (fig. 10). The operculum of the cast (fig. 10) is triangular.

#### PENTANEURA PELEENSIS (Walley)

Three pupal casts (fig. 8) (nos. 561a, 561b, 1370). Length 5.4 mm. Brown tints very faint. Shagreen fine. Respiratory organ (fig. 9) .64 mm. long, with a conspicuous tube from the apex encased in a clear integumentary coat and bifurcated distally with disk-like flattened areas exposed to the surface. The



Figs. 2-7. Hypopygia of *Pentaneura* spp.,  $\times 132$ .—2, *P. pelecensis* (Walley). 3, *P. melanops* (Wied.). 4, *P. flavifrons* (Joh.). 5, *P. okoboji* (Walley). 6, *P. pilosella* (Loew). 7, *P. nigropunctata* (Staeg.).

tube is highly extensible, in the preserved cast about one-third as long as the organ. Apparently this is an adaptation for breathing in water that is covered by a thick surface film. The respiratory organ is covered with rather coarse prickles that point distad. Between the two respiratory organs there is a transverse row of 18 to 20 long, conical, pointed spinules irregularly alternating long and short, and at the lateral end of this row, near each respiratory organ, is a large brown spine that is apparently fibrous in structure (fig. 9). This respiratory organ and accessories are similar to Zavrel and Thienemann's *Peritaphreuusa zavreli* Kieffer described by them on page 704, fig. 20a; or to that of *Tanypus guttipennis* V.d.W. figured by Goetghebuer 1927 (fig. 95, p. 71) except that in ours the respiratory tube is much larger. The prickles on the lateral margin of the fin lobes are quite conspicuous. The operculum of the cast (fig. 9) flares broadly.

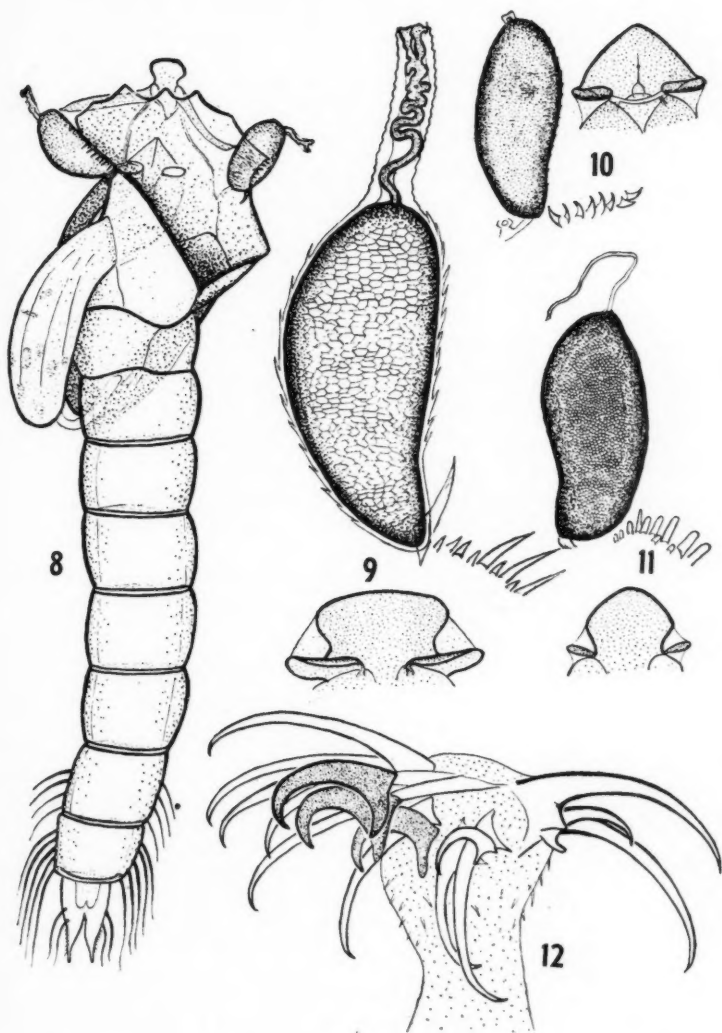
The larvae we have are not well preserved and inadequately identified with one exception (no. 350). The adult of this specimen is a female and is tentatively classified as *P. mallochi*, a determination strengthened by the fact that the pupal cast of this specimen agrees with the other *P. mallochi* casts described above. This larva agrees in detail with the description of the larva of *P. monilis* of Johannsen 1937, and the more detailed description of Zavrel and Thienemann 1921, page 697, except in one conspicuous particular: the claws on the posterior prolegs (fig. 12) are long, yellow with three very dark brown claws among them instead of two as is the case in all other described species of the *monilis* group. For the rest the following description may be of value: Length of head .866 mm., breadth of head .471 mm., giving a ratio of 1.83 to 1, or a cephalic index of .55. Basal segment of antenna .385 mm. long, the sum of the other segments about .89 mm., giving a ratio of .43. The full length of the antenna is .55 the length of the head. The mandible is Thienemann's Type I (p. 583, fig. 12B); the maxillary palp is like Thienemann's figure 51, p. 698. The glossa and paraglossa are typical (Thienemann, fig. 17, p. 588). In a word the detailed description of the larva of *P. monilis* given by Thienemann agrees with our specimen except for size and the claws of the posterior prolegs. The last difference, however, is quite striking.

#### B. OTHER SPECIES OF PENTANEURA FROM IOWA

The following species are listed to complete our Iowa record for this genus. We have appended our own drawings of the hypopygia since these are not found in the literature.

##### PENTANEURA CARNEA (Fab.) ? (Group C of Edwards)

A pupal cast taken from Forest Park Creek near Davenport on April 17, 1941, agrees with Johannsen's description of *P. carnea* in all details. A teneral specimen of an adult male taken on May 10, 1942, is doubtfully placed here; its hypopygium seems identical with that of *P. monilis*, and it may be the latter species though there are no visible bands on the tibiae.



Figs. 8-12.—8, Pupal cast of *P. pelecensis* (Walley),  $\times 24$ . 9, Respiratory organ, row of spinules and operculum of cast of *P. pelecensis*,  $\times 80$ . 10, Same of *P. mallochi*. 11, Same of *P. basalis*. 12, Claws on posterior proleg of larva of *P. mallochi*,  $\times 170$ .

*PENTANEURA FLAVIFRONS* (Joh.) (Group D of Edwards)

Males taken on May 11 and 12, 1941, at Davenport seem to be typical (see hypopygium, fig. 4). One taken on July 23 has the same hypopygium but lacks the brown bands on the abdominal tergites and has in place of them a median longitudinal brown streak extending from segments 3 to 6 with clear oval areas in the streak.

*PENTANEURA MELANOPS* (Wiedemann. Meigen?)

(Group D of Edwards)

This species is quite common in Davenport from April to August; there is also one specimen from Okoboji, Ia. See hypopygium figure 3. Reared from larvae taken in creeks.

*PENTANEURA OKOBOJI* (Walley 1928)

One male, August 1941, Davenport. See hypopygium figure 5. This species was described by Walley from one male specimen taken at Okoboji, Ia., on May 18, 1928.

*PENTANEURA PILOSELLA* (Loew).

Fairly common June to September in Davenport. Swarming at Okoboji in August. See hypopygium figure 6.

*PENTANEURA NIGROPUNCTATA* (Staeg.).

Three males, April 25 and August 11, Davenport. See hypopygium figure 7.

## C. ECOLOGICAL NOTES

The Tanypodinae do not construct tubes. They are carnivorous and quite commonly cannibalistic. However, according to Thienemann and Zavrel (1921, p. 636) they seem also to be fond of microscopic plant life: I have found the gut of the larvae filled with diatoms. The constant activity of these larvae seems to be a never ending search for food. Leathers (1922) gives a good description of their feeding habits. According to his observations on *P. carnea* this tanypod kills its prey and sucks the contents which very often include large number of diatoms. This fact throws doubt on the theory that they eat the living diatoms of their environment.

*Pentaneura monilis* according to Thienemann breeds only in clear, deep water, not in polluted waters. Malloch (1915) reports that *P. monilis* breeds commonly in the Illinois River. However, his report that it was found breeding in a rain barrel is, to my mind, doubtfully correct. It is very easy to confuse the several species of this group in the immature stages. The adults are very common near the Mississippi and at Okoboji, but since we have not collected systematically in deeper waters we have never found the immature stages of *P. monilis*. The species that we have been able to breed in the laboratory are those described above and they are all found in shallow ponds and slow moving



streams. Muttkowski's remark (1918, p. 409) that *P. monilis* is a littoral form seems to be another case of mistaking related species for the type of the group. Adams (1940) states that "some believe *T. peleensis* (and some other named forms) to be a variety of *monilis* L." The pupal casts described in the present paper should definitely remove that suspicion.

Adult chironomids generally may be found far from their breeding places, probably carried by the wind over considerable distances. For this reason one should not expect to find well defined geographical races, but rather ecological varieties that will be quite similar in widely separated areas of the country and even on different continents.

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## A Comparison of Flights of Four Species of Ants

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Flights of ants are often conspicuous enough to attract the attention of biologists and non-biologists alike. Almost everyone has seen winged ants pour out from places where no ants had been noticed before, cover the ground and fill the air for a few hours and then disappear again. However, few studies have been made concerning the environmental conditions under which the flights take place, or the flight activities of different species of ants.

This article compares the rather diverse types of flights of four species of ants belonging to four different genera. *Myrmica schencki emeryana* Forel, *Formica pallidefulva schaufussi incerta* Emery, and *Lasius niger alienus americanus* Emery—all nesting in the Talbot yard at Tiffin, Ohio, and *Prenolepis imparis* Say, nesting in an apple orchard at St. Charles, Missouri. For all species the flight records used are those of 1943. Observations of other years, however, lead to the belief that these were typical.

The ordinary concept of ant flights seems to be that there is one flight day each year for each species and that on this day all of the colonies of a large territory take part in one conspicuous swarm. But it was found that, for these four species at least, flights are spread over several days, not all of the colonies of an area are necessarily active on all of the days, and not all of the individuals of a colony need take part in any one flight. Flights may be inconspicuous as in the case of the *Formica* or *Myrmica* studied or very conspicuous as in the case of *Lasius* and *Prenolepis*.

### LASIUS NIGER ALIENUS AMERICANUS Emery

*Lasius niger alienus americanus* is the most common ant of this region, nesting in great abundance in the lawns about dwellings. Because the colonies are numerous and each produces many winged ants, flights are often noted. Flights always occur in the late afternoon of late summer or early autumn (Table 1).

TABLE 1.—A summary of conditions under which flight took place in 1943.

|            | Time of year                 | Time of day*     | Temperature | Relative humidity |
|------------|------------------------------|------------------|-------------|-------------------|
| Prenolepis | March 25, 29, 30             | 10 a.m.-3 p.m.   | 71°-84° F.  | 38%-45%           |
| Myrmica    | July 16, 19, 20, 21          | 6 a.m.-8 a.m.    | 64°-74° F.  | 63%-84%           |
| Formica    | July 21, 23, 24              | 8 a.m.-10 a.m.   | 76°-85° F.  | 58%-79%           |
| Lasius     | Aug. 30, 31; Sept. 4, 15, 28 | 3:30 p.m.-6 p.m. | 71°-81° F.  | 63%-91%           |

\* Central Standard Time.

*Lasius* showed decided pre-flight activities by enlarging the entrances of nests from the original small ones about  $1/16$  in diameter to conspicuous holes  $1/4$  to  $1/2$  inch in diameter. In 1943 this enlarging began on August 28, after two days of cold rain. On this day also males were seen for the first time, but they stayed down in the entrances and did not venture to the surface. Next

afternoon there was a general emergence of males, as many as 40 or 50 spreading out about a nest and climbing near-by grass blades. At about 4 o'clock a few males flew, but this was not considered to be a real flight because no females were present, and most males simply milled about for a time and then returned to the nest. August 30th was a typical flight day. As early as 2 p.m. a few males were gathered just inside the nest entrances but not until 4:15 did they begin to come to the surface. The first females did not appear until 4:25. Workers became very active, moving about among the winged ants and climbing up and down grass stems in large numbers. By 4:45 the flights were well under way; at each nest entrance there were several hundred males, numerous workers, and perhaps 8 or 10 females. The males were moving in rapid, jerky fashion, opening and closing their wings, climbing grass blades, and running down again and up other blades, and at last taking off into the air. Females were more deliberate in their movements, but they also climbed up and down grass blades before flying. However, when they did fly they took off easily and flew up into the air. At the peak of flight the whole yard seemed moving with ants, the little pools of activity about each nest enlarged and merged until almost the whole surface seemed involved in the action. The air too became filled with flying ants which were rising constantly from the earth. Toads came out and settled beside colonies for good meals. Flight seemed still at its height at 5:30 though the sun's rays were slanting low across the grass, but by 5:40 the males and females which had not flown were making their way back into entrances and by 6:00 all were in the nests. However, many workers were still moving about in the dusk.

Next day (August 31) was dull, hot, and sultry, and these conditions brought about an earlier and more intense flight. More ants were out and more flying. Males were thick on grass blades, sometimes 5 or 6 to a blade, their wings flashing brightly in the light. They never seemed to stop their quick, jerky movement, but the more leisurely females often paused on grass blades before crawling down or flying away. Heights of flight extended from approximately 3:45 to 4:45 p.m., thus beginning and ending earlier than the night before. By 5:30 all of the remaining winged ants were again in their nests.

The next three days were hot and dry and no winged ants appeared, but after hard rains in the morning of September 4th an afternoon flight occurred. At 3:30 there was still no sun, and the air was heavy and oppressive. Workers were actively digging out entrances which had been filled up during the rain, and males were beginning to come out from the enlarged openings. By 4:20 flight was in full swing and seemed to exceed previous ones. At 5:15 the light was failing, and flight was about over.

Next day seemed exactly right for another flight, since there was another rain in the morning and temperature and humidity conditions seemed favorable, but no winged ants even came above ground. The next few days seemed equally suitable for flight, but none occurred until September 15th. This flight took place between 4 and 5:30 p.m. and just preceded a rain. After this, there was a frost followed by a series of cold days, and flights seemed definitely over for the year; but on September 28th the temperature rose again and that afternoon there was a final sparse flight.

Thus flights of *Lasius* seemed to be associated with rain, especially with approaching storms. However, ants did fly on clear days, and on some days when temperature, humidity, and dampness of the ground seemed perfect, no flights occurred.

Before flight time 30 nest entrances were staked. This does not necessarily mean that 30 colonies were studied since the extent of *Lasius* nests beneath ground and the number of entrances belonging to each colony is not known (Headley, 1941). Of these 30 entrances 15 were not enlarged before flights, nor did ants from them take any part in the flights. The 15 enlarged entrances all produced winged ants on the first day of flight, but on the second day only 12 were active, and on subsequent flight days the number of active entrances dwindled to 10, 5, and 3. Once a colony entrance became inactive it did not resume activity in later flights.

*Lasius* colonies produce a great preponderance of males. During flights there seemed to be more than 100 males to every female. Of the 15 "colonies" staked, 9 had only males while the remaining 6 had both males and females. One of the 6 was almost a female colony, only a few males being present.

#### PRENOLEPIS IMPARIS Say

*Prenolepis* is another ant whose flights may be conspicuous. In contrast to the fall flights of *Lasius*, *Prenolepis* flies in early spring. One may venture the generalization that flights occur during the warmest parts of the first days of spring when the temperature reaches 70° F. or above (Table 1). In 1943 the first flight occurred on March 25 and lasted from 10 a.m. to 2:30 p.m.; the second flight on March 29 was later in the day, 1 to 3 p.m., because the morning had been cloudy and cool and the temperature did not rise until afternoon; but the third flight period on March 30th was typical, lasting from 10 a.m. to 3 p.m. Days between flights were cold. (For flight records of 1941 and 1942, see Talbot '43b).

Pre-flight activities consist of multiplying nest entrances beyond the usual one, and of exploratory aboveground excursions made by the males. Usually these activities take place over a period of several days but in 1943 the first warm day of spring came rather suddenly so that multiplying of entrances began only four days before flight (noon temperature 44° F.). By the time of the first flight day 10 nests under observation possessed 17 entrances and before the second day of flight there were 23 openings.

On each flight day males emerged before the females and ran about on the ground and up grass blades for a time before flying began. *Prenolepis* males are small, active insects which tend to fly in swarms just a few feet above the surface of the ground. Females are large and heavy, and while they continually and actively climb blades of grass and flutter their wings, in most cases they simply fall back to the ground or fly only a few feet. Consequently most mating took place upon the ground. Males seemed aware of females at a short distance and would follow them from one grass blade to another. In mating, the much smaller male attached itself to the female's abdomen and either curled up over her back or extended, upside down, straight out behind. Mating lasted two minutes or less, and multiple mating occurred. One female mated

twice within ten minutes and then tore off her wings and went down among some dry leaves. Tearing off of wings occurred soon after mating, and then the female usually ran about in the grass for a while before moving down into some crevice or under a leaf or bit of bark. One female broke off her wings while a male was still attached, and one wingless female was seen to mate.

*Prenolepis* flights were quite conspicuous since many colonies were aggregated in the orchard. The air seemed filled with flying males, and everywhere upon the ground were little groups of males and females clustered about nest entrances. Workers took part in the flight by coming out in great numbers and moving about among the winged forms. At the close of each day's flight most of the remaining males and females went back into the nests unassisted, but a few males were carried back by workers.

Of ten *Prenolepis* colonies under observation, each produced both males and females and all took part in the first flight; however, two colonies took no part in the second day of flight and five showed no activity on the third day. There were always many more males than females produced by a colony. Eleven colonies whose populations were counted (Talbot '43a) showed an average of 153.4 males and 19.6 females or 7.8 males per female.

#### MYRMICA SCHENCKI EMERYANA Emery

*Myrmica emeryana* flies during the cool of the early morning on midsummer days. In 1943, records were kept for three nests, two of which were only 16 inches apart. Flight activities began shortly after sunrise and lasted about two hours. At this time the nests were still in the shade and the air was cool (64°-74° F.). Ends of flights corresponded to the times when the sun reached the nests and temperatures rose abruptly. Flights were not resumed in the late afternoon when temperatures dropped again, although a few females regularly came out again at that time. Two of the three colonies observed had flights on four different days (Table 1), but the third colony continued to have sparse flights for 5 more days (July 24, 25, 27, 31, and August 1).

The nest of this species of *Myrmica* has a single opening, usually surrounded by a little chimney of grass blades. There is no pre-flight modification of this entrance; males and females climb over the top of the turret just as workers do. In this species it is the females and not the males which appear above the ground before flight. Winged females began to appear on the ground about the nests seven days before flights commenced, coming out in the early morning and again in the late afternoon. Usually there would be only two to six at a time, and they kept very near to the nest entrance, walking slowly, and acting very much as workers do, even to eating bits of apple placed near by. They were entirely undisturbed by any worker.

On July 12th there began a peculiar and unexplained maneuvering between two nests, the turrets of which were close together. Workers were found to be carrying males from nest A to nest B, and either pulling them down into the entrance or releasing them beside it and guiding them down. At the same time a number of females were seen to walk from nest B to A and enter, and a fewer number reversed the procedure by going from A to B.

Workers were also carrying a few pupae and larvae between the nests in both directions. There was never more than one or two of these workers carrying males and brood to be seen at a time, and during midday they stopped activity entirely. At first it was thought that the colonies were exchanging males and females, but although all the males were taken to nest B, the original nest of the females could not be told because they were going in both directions.

Flights began on July 16 and since they were essentially similar for all three colonies observations of nest A will be described here. At 6 a.m., instead of the 2 or 3 females that had been usual for a week, there were 8 to 10 females near the nest opening or climbing up blades of grass. Two males were also in sight, but they were being pulled at by the workers and were pushed down into the nest again. By 6:10 the ants were coming out of the nest in a procession. Females moved about and climbed grass blades undisturbed, but a group of workers near the entrance pulled at the males and occasionally got one back into the nest.

By 6:20, 25 females and 15 males were walking over the ground and up grass blades in all directions from the nest in a radius of 6-8 inches. Twenty-five or thirty workers were moving among them. Since this proved to be as much activity as ever occurred at one time, all of the flights are slow and unspectacular. The ground area covered was small, and all movements were slow. Females moved no faster than the workers and, continuously climbed grass blades, hesitated on them, then climbed down and up others without even so much as trying their wings. Males moved almost as slowly, and very few flew. At no time during the flights was there a group of flying ants in the air. By 7:30 activity had slowed down, for at this time no males were seen and females were working their way back to the nest opening. By the time the sun's rays had reached the nest (7:50) only 2 females were above ground.

The next two days were rainy and cold, and while a few winged ants were above ground in the morning and again in the late afternoon, no flying occurred. On the second day of flight (July 19th) there were already two females and a male in sight at 4:30 a.m. but general emergence did not begin until 6:05. By 6:25 there was the typical flight activity with males and females and workers walking about in their leisurely fashion. This day a few females, as well as males, flew, but most continued their aimless wanderings up and down grass blades. At 6:50 flight was at its height with 24 females, 6 males, and 15 workers in sight. But again, only a few ants flew, and by the time the sun had reached the nest, those remaining which had not already returned to the nest made their way back to its entrance. On the third day (July 20th), flight activities began at about the same time but stopped earlier (6:45). There were fewer ants out (not more than 11 females and 2 males were ever seen at a time), but more of both males and females were seen to fly. On the fourth day of flight (July 21st) there were almost no males left, and more females were seen to fly than previously. This day served to clear the nest of winged forms, for none were seen hereafter. The second colony had almost identically the same type of uneventful flights, and these occurred on the same 4 days, but the third colony went on having flights at the same time each morning for



5 more days. At the end of these 9 flight days one female with crumpled wings was still persistently climbing up and down grass blades.

Contrary to the procedure for *Lasius* and *Prenolepis*, *Myrmica* produced more females than males. Ten colonies in which winged forms were counted averaged 60.8 females and 18.7 males per nest or 3.3 females for each male. Six of those nests contained both males and females, three produced only females, and one (a colony without a queen) contained only males.

*FORMICA PALLIDIFULVA* SCHAUFUSSI INCERTA Emery

Only one *Formica* colony was available for observation and this produced only females; however, the 1942 and 1943 records for this colony were almost identical. In 1942, flight days were July 12, 13, 15, and 18; in 1943, July 21, 23, and 24. These dates overlapped flight days of the *Myrmica* colonies close by. But *Formica* flights began at just the time of day when *Myrmica* flights stopped—when the sun reached the nest and the temperature rose (71°–85° F.). Flights lasted two hours or less (8–10 a.m.), and there seemed to be no environmental reasons for the cessation of flight each day. July 22, when flight did not occur, was cold and wet.

The workers did not enlarge the single nest entrance, nor were any females seen before the time of flight. And flight itself reached heights of inconspicuousness. Usually only one female came from the nest at a time, she was above ground for about 30 seconds before flying, and intervals between emergence of females varied from 2 to 9 minutes. Each female went through essentially the same set of actions. She came from the darkness of the nest by way of a cross gallery about an inch below the surface, loitered in this little vestibule for about 2 to 5 minutes and then climbed to the top of the gallery and out upon the ground. She then began quick wasp-like movements with her antennae and ran in quick, wasp-like fashion across the grass and up a grass blade. At its tip she spread her wings and flew without a second's hesitation, spiralling upward to housetop level and then out of sight. Most females flew within 6 inches of the nest, but a few varied the procedure slightly by running farther, stopping occasionally under grass blades, or climbing and falling several times before succeeding in flight. Two or three continued to run about on the ground and never were seen to fly.

Since only one female (rarely 2 or 3) was in sight at one time, since they flew almost immediately and intervals between the emerging of females were long, and since no workers gathered at the entrance, these flights were truly inconspicuous. Casual observation even during what might be called the peak of flight might reveal nothing. This lack of congregating for flight corresponds to the condition in *Formica rufa obscuripes* Forel as reported by Neal Weber (1935). He says, "Commonly but one or a few take flight at the same time but, whether if the same or opposite sex, they do not fly in a group. Thus there is not the slightest indication of a nuptial flight."

The colony did not produce many females. In 1943, 20 were seen to fly, and this probably represents at least  $\frac{3}{4}$  of the total. Twelve were the most to leave the nest in one morning.



## SUMMARY

In 1943 *Lasius niger alienus americanus* flights occurred on August 30th, 31st, and September 4th, 15th, and 28th. They took place in the late afternoon between 3:30 and 6:00 p.m. (central standard time) when the air was cooling (71°-81° F.) after warm days. Rain or approaching storm seemed to stimulate flights but was not a necessary stimulus. Before flight days, nest openings were enlarged, and males made preliminary excursions above ground. Flights were very conspicuous over a whole district because colonies were numerous and many ants appeared at each nest so that the ground was covered and the air filled with flying ants. Males outnumbered females at least 100 to 1, and some nests had only males. Some colonies took part in all of the flights, but most did not.

*Prenolepis imparis*, in contrast, flew in the early spring on March 25th, 29th, and 30th in the warmest part (10 a.m.-3 p.m.) of the first warm days (71°-84° F.). Before flight, entrances to the nests were multiplied and males began appearing above ground. During flight, males flew in swarms from 4 to 6 feet above the surface, but the larger females flew little at all; consequently most mating took place upon the ground. Males outnumbered females about 8 to 1. In places where nests were abundant, flights were almost as conspicuous as were those of *Lasius*. Not all of the colonies took part in all of the flights.

*Myrmica schencki emeryana* flights were on July 16th, 19th, 20th, 21st for 2 colonies observed, but a third colony had 5 additional flight days on July 24th, 25th, 27th, and August 1st. These flights took place in the early morning (6-8 a.m.) while the air was still cool (64°-74° F.). No pre-flight nest modifications were made, but females came out each morning and evening for a week before flight. Flights were inconspicuous because few nests were present, winged ants stayed close to the nests and never flew in numbers. Females outnumbered males 3 to 1.

*Formica pallidefulva schaufussi incerta* flights took place at about the same time of year as did those of *Myrica* (July 21st, 23rd, 24th) and in time of day followed immediately after them (8-10 a.m.) when the temperature had risen (76°-85° F.). Flights from the one nest observed were very inconspicuous. No pre-flight activity took place, workers did not gather about the nest during flight, and the winged females left the nest singly, quickly, and at infrequent intervals.

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## New Species and Records of Cheliferid Pseudoscorpions<sup>1</sup>

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While working on the pseudoscorpion collections of the Illinois State Natural History Survey and the American Museum of Natural History, the writer found two new species of the genus *Hysterochelifer* Chamberlin, 1931, as emended by Beier (1932). The present paper gives the descriptions of these two new species and in addition gives new records for *Dactylochelifer copiosa* Hoff.

The descriptions are based on specimens cleared in beechwood creosote and mounted in Canada balsam. Previous to clearing, the body but not the appendages of each individual was treated with potassium hydroxide solution. All drawings were made with the aid of a camera lucida. Types are deposited with the Illinois State Natural History Survey at Urbana, Illinois.

### *Hysterochelifer longidactylus*, new species

Figs. 1-6

*Male*.—Unknown.

*Female*.—Body moderately large and stout, length about 2.5 mm.; holotype light yellow, palps with greenish tinge; paratype darker yellow with reddish-yellow palps; palpi slender, legs moderately stout; nearly all parts of body moderately to coarsely granular. Carapace subtriangular; widest across the posterior margin, width subequal to length; ocular width about 0.43 mm.; eyes of the single pair large, well developed; posterior margin of carapace straight with a marginal row of ten short, terminally denticulate setae; lateral margins weakly but evenly convex; anterior margin convex, with four multidenticulate setae; numerous short setae scattered over sides and dorsal surface; two transverse furrows, the anterior one nearly midway between the anterior and posterior margins of the carapace.

Abdomen oval in general shape; slightly more than two-thirds as wide as long. Tergites conspicuously divided, surface marked by poorly elevated, scale-like granulations; each tergite with a single marginal row of setae and often a medial and a lateral seta anterior to the others of the row; setae subclavate; first tergite with ten to twelve setae, tergites two through ten with twelve to sixteen setae, tergite eleven with several setae including a pair of longer acuminate setae. Sternites divided, weakly sculptured; setae longer than tergal setae, slender and acuminate, forming a single marginal row except for a lateral seta on each half sternite on the posterior portion of the abdomen; most sternites with twelve to fourteen setae and two or more pairs of microlyriform fissures.

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Anterior stigmatic plates devoid of setae; each posterior stigmatic plate with one seta. Pleural membranes with numerous fine, parallel striations.

Chelicera: Base with net-like markings; five setae present, the laminal and interior setae much longer than the others; flagellum of three blade-like setae, the longest with a few fine serrations along the anterior margin some distance from the tip; for measurements, see table 1. Fixed finger with wide lamina exterior; apical tooth with three denticles on the concave surface followed immediately by three larger teeth on the inner margin of the finger; distal four teeth of the serrula interior free and with margin serrate, more basal teeth fused into a velum. Movable finger with sickle-shaped apical tooth, tip often divided into two or three weakly defined cusps; subapical tooth acute, conical, placed close to the base of the apical tooth, galeal seta reaching beyond the tip of the galea; inner margin of finger with a very small denticle near the level of the base of the galeal seta; galea straight, base stout, five to seven spine-like side and terminal branches confined to the distal one-half; serrula exterior composed of about eighteen ligulate plates (chelicera of one side in female paratype with twenty-one plates), of which the proximal one and to some extent the next are longer than the remainder.

TABLE 1.—Measurements (in mm.) of type specimens of *Hysterochelifer longidactylus*, new species. L, Length; W, Width; D, Depth.

| Measurements                       | Holotype<br>(female)<br>(Illinois) | Paratype<br>(female)<br>(Arkansas) | Paratype<br>(tritonymph)<br>(Illinois) |
|------------------------------------|------------------------------------|------------------------------------|--|
| Carapace L. × W. ....              | 0.82 × 0.85                        | 0.865 × 0.82                       | 0.70 × 0.595                           |
| Abdomen L. × W. ....               | 1.7 × 1.2                          | 1.7 × 1.2                          | 1.55 × 0.95                            |
| Chelicera L. × W. ....             | 0.235 × 0.15                       | 0.23 × 0.15                        | 0.175 × 0.13                           |
| Cheliceral finger L. ....          | 0.194                              | 0.19                               | 0.155                                  |
| Palps: Maxilla L. × W. ....        | 0.405 × 0.29                       | 0.430 × 0.27                       | 0.335 × 0.22                           |
| Trochanter L. × W. ....            | 0. .... × 0.25                     | 0.405 × 0.24                       | 0.295 × 0.178                          |
| Femur L. × W. ....                 | 0.87 × 0.19                        | 0.83 × 0.193                       | 0.61 × 0.152                           |
| Tibia L. × W. ....                 | 0.655 × 0.22                       | 0.65 × 0.232                       | 0.465 × 0.17                           |
| Chela L. × W. ....                 | 1.41 × 0.35                        | 1.41 × 0.36                        | 1.04 × 0.248                           |
| Chela D. ....                      | 0. ....                            | 0.315                              | 0.23                                   |
| Hand L. (without pedicle) ....     | 0.675                              | 0.665                              | 0.47                                   |
| Finger L. ....                     | 0.79                               | 0.785                              | 0.55                                   |
| Leg. I: Pars basalis L. × D. ....  | 0.247 × 0.163                      | 0.235 × 0.158                      | 0.175 × 0.129                          |
| Pars tibialis L. × D. ....         | 0.345 × 0.14                       | 0.327 × 0.14                       | 0.250 × 0.114                          |
| Tibia L. × D. ....                 | 0.35 × 0.095                       | 0.33 × 0.095                       | 0.255 × 0.0835                         |
| Tarsus L. × D. ....                | 0.365 × 0.072                      | 0.365 × 0.076                      | 0.275 × 0.079                          |
| Leg. IV: Pars basalis L. × D. .... | 0.25 × 0.18                        | 0.243 × 0.165                      | 0.19 × 0.137                           |
| Pars tibialis L. × D. ....         | 0.575 × 0.265                      | 0.575 × 0.267                      | 0.432 × 0.193                          |
| Entire Femur L. × D. ....          | 0.70 × 0.265                       | 0.69 × 0.267                       | 0.53 × 0.193                           |
| Tibia L. × D. ....                 | 0.53 × 0.145                       | 0.53 × 0.133                       | 0.384 × 0.1065                         |
| Tarsus L. × D. ....                | 0.415 × 0.094                      | 0.415 × 0.095                      | 0.315 × 0.0835                         |

Palpus: Relatively slender; setae short, multidenticulate to simple acuminate; surface very granular except on maxilla and chela; measurements given in table 1. Maxilla weakly granular; setae acuminate, scattered, mostly short; two apical setae; length about 1.5 times the width. Trochanter with numerous short, terminally multidenticulate setae; two sublateral protuberances; inner

margin evenly convex. Femur with setae of inner surface slightly heavier and with more denticulations than setae of outer surface, all setae relatively short; weakly developed pedicle, wider than long; femur with outer margin weakly convex; inner margin very weakly concave; length 4.6 times the width in the holotype, 4.3 times in the paratype. Tibia with granulations and chaetotaxy as in the femur; pediculate, the pedicle being about as long as wide; both margins unevenly convex, the outer margin being slightly flattened in the basal half distal to the pedicle; length 2.95 times the width in the holotype, 2.7 times the width in the paratype. Chela slender; outer margin weakly convex, inner margin more convex; hand tapering gradually to join the fingers; setae of hand scattered, short, very minutely paucidentate near the tip; setae of fingers long and acuminate; chela virtually smooth except for a few fine granulations on the inner surface of the hand; length about 4.05 times the width in the holotype, 3.9 in the paratype; depth of chela somewhat less than the width; length of movable finger considerably more than the length of the hand without pedicle; finger in dorsal view slender, evenly but conspicuously curved. In lateral view, hand appears subrectangular with the dorsal margin evenly convex, the ventral margin less convex. Fingers in lateral view slender; fixed finger with outer margin weakly convex, inner margin almost straight; movable finger with outer margin somewhat convex, inner margin very slightly concave; venedens slender and acute in both fingers. Marginal teeth of both fingers well developed, retroconical, contiguous, wider than high, becoming weak at the proximal end of the row; the more than forty teeth forming a row extending from near the base of each finger to the tip; teeth of paratype so greatly worn that nearly all teeth appear blunt and rounded. Fixed finger with eight tactile setae: *et* between one-fifth and one-sixth of finger length from tip, *it* as far from *et* as latter is from finger tip; *est* and *ist* on the same level or with *est* slightly distal to *ist*; position of *est* and *ist* somewhat variable but always proximal to the midpoint of the finger and farther from *it* than the latter is from *et*; *eb* at very base of finger, *esb* about two areole diameters from *eb*; *ib* little distal to the level of *esb*; *isb* about two areole diameters from *ib*. Movable finger with four tactile setae: *t* about three-eighths or slightly more of finger length from tip; *b* near base of finger; *ib* about two areole diameters from *b*; *it* approximately midway between *b* and *t*. Nodus ramosus of fixed finger somewhat basal to the level of *it*; of movable finger slightly basal to level of *t*.

Legs: Scale-like surface granulations more conspicuous and coarser on the femora than elsewhere; setae relatively short, varying from simple acuminate to paucidentate; for most measurements see table 1. First leg with posterior protuberance on trochanter; trochanter but little longer than deep, setae spine-like, paucidentate, few in number; pars basalis with length about 1.5 times the depth, slightly pedunculate, flexor margin weakly convex, setae as on the trochanter; pars tibialis with length 2.35 to 2.45 times the depth, both margins weakly convex, flexor margin coarsely granular, setae as in pars basalis; flexor margin of tibia weakly convex with a few acuminate setae, extensor margin very weakly S-shaped with paucidentate setae, length 3.5 to 3.7 times the depth; tarsus tapering towards the tip, deepest near the basal third or fourth, setae numerous but otherwise as in the tibia, surface sculpturing very weak,

length about 5.0 times the depth. Fourth leg with surface sculpturing weaker than in first leg, setae of flexor margin of podomeres acuminate, setae of extensor margin spine-like and paucidenticate especially in the basal podomeres; trochanter 0.20 mm. deep, length about 1.5 times the depth, both margins convex, flexor surface with numerous moderately long acuminate setae especially on the distal half, extensor surface more granular and with a relatively few short paucidenticate setae; pars basalis short, length 1.4 to 1.5 times the depth, several acuminate setae on the flexor surface; pars tibialis with a few short but acuminate setae on the flexor surface and a few paucidenticate setae on the extensor surface, extensor margin very convex, flexor margin straight and continuous with flexor margin of pars basalis; entire femur with length 2.6 to 2.65 times the depth; tibia with evenly convex flexor margin, extensor margin almost straight except near basal end, chaetotaxy as in pars tibialis, length 3.65 (holotype) to 3.95 (paratype) times the depth; tarsus with weakly concave flexor margin, extensor margin convex, setae much as in tibia but more numerous, length about 4.4 times the depth; sensory setae about 0.7 of the length of the tarsus from the proximal margin.

Genital complex: Posterior operculum little modified, twelve to fourteen setae present in a single marginal row. Anterior operculum with a group of seven or eight setae arranged in a compact row on each side of the median line. Lateral cribiform plates with diameter about twice as great as the plates of the median pair; all cribiform plates well separated.

*Tritonymph*.—General shape and features as in the female but smaller, measuring about 2.3 mm. in length; carapace with fewer setae on surface and sides than in the female, otherwise similar; abdomen less sclerotic, perhaps a little more slender than in the female; tergites divided; each tergite with eight or ten setae, never more; setae of same general type and arrangement as in the female; sternites five to ten, with eight to ten acuminate setae in each; sternite four with five setae. Stigmatic plates and pleural membranes much as in the female.

Chelicera: Galea with four or five terminal and subterminal branches; subapical lobe poorly developed; serrula exterior with about fourteen plates; otherwise much as in the female.

Palpus: Chaetotaxy (except tactile setae of fingers) and sculpturing much as in the female; dimensions shown in table 1. Pedicles of femur and tibia weakly set off from the rest of the podomere; length of femur 4.0 times the width; length of tibia 2.75 times the width; chela with hand more slender than in the female, length 4.2 times the width, depth little less than the width; movable finger longer than hand without base. In lateral view, chela much as in the female except that the fingers appear a little stouter and each has about thirty-five marginal teeth. Fixed finger with seven tactile setae: *ib*, *isb*, *eb*, and *esb* much as in the female; *et* about one-fifth of finger length from tip; *est* about twice as far from *et* as the latter is from the finger tip, being about midway between *et* and *eb*; *it* closer to level of *est* than *et*, about midway between finger tip and *ib*; *ist* lacking. Movable finger with three tactile setae: probably *sb* lacking; *t* slightly less than two-fifths of finger length from tip; *st* very

slightly more than one-fourth of finger length from base; *b* nearer to base than to *st*.

**Legs:** Legs much as in the female except smaller, many podomeres stouter, and fewer setae present. First leg with length of pars basalis 1.35 times the depth; length of pars tibialis 2.2 times the depth; tibia with length 3.05 times the depth; tarsus much stouter than in the female, length only 3.5 times the depth. Fourth leg with the extensor margin of the tibia weakly S-shaped and the flexor margin of the tarsus weakly convex; length to width ratios of podomeres much like those of female except that the tarsus is much stouter, being about 3.8 times as long as deep; sensory seta of tarsus about two-thirds of length of tarsus from the proximal end.

**Type Locality.**—The female holotype and a tritonymph paratype occur in a collection made by Ross, Ross, and Beaver on July 10, 1943, from the bark of a cut hickory one and one-half miles northeast of Mahomet, Champaign Co., Illinois; the female paratype was collected by M. W. Sanderson on July 29, 1940, in Washington Co., Arkansas. Habitat details of the last specimen are unknown.

**Remarks.**—Examination of the literature reveals that nine species already have been assigned to the genus *Hysterochelifer*. Of these, only two have been reported from the nearctic region, the remainder are from widely scattered paleartic areas. *Hysterochelifer longidactylus* may be separated from the paleartic species of the genus by characteristics of the palpi, separation in most cases being based on the more slender palpus in which the chelal finger length in our form exceeds considerably the length of the hand without the pedicle. With respect to species of *Hysterochelifer* from the nearctic region, separation may be made on the basis of palpal as well as other reliable characteristics. In both *H. fuscipes* (Banks, 1909) and *H. geronimoensis* (Chamberlin, 1923) the fingers are stout and at least no longer than the hand and the body length is only 1.8 mm. and 2.1 mm. respectively while in *H. longidactylus* the fingers are slender and longer than the hand and the body length is about 2.5 mm. Separation of the present species from *H. callus*, new species, also described in this paper is given under the discussion of the latter species.

The present species is based on only three individuals, two females and one tritonymph. Since the females come from different localities and different population groups, differences between the two have been carefully recorded. These differences are probably not beyond the limits to be expected in many species of pseudoscorpions and further collecting may make specimens available for more accurate determination of intraspecific variation.

#### *Hysterochelifer callus*, new species

Figs. 7-12

**Male.**—Color of body and palps brown; legs brownish-yellow; all body parts conspicuously granular; palpus, without maxilla and trochanter, longer than body; length of body 1.7 mm.; description of male based on holotype. Carapace brown in color, evenly and moderately to coarsely granular; no larger



granules interspersed among the others; length 0.60 mm.; width greatest at the posterior margin and about 1.1 times the length; two large eyes; ocular breadth 0.35 mm.; posterior margin straight, with ten very short and terminaly paucidentate marginal setae; anterior margin short and very little convex; lateral margin rounded and convex anterior to the median transverse furrow, but little convex between the furrows, flaring out suddenly near the posterior margin; scattered setae on dorsal and lateral surfaces of carapace extremely small; transverse furrows well marked, the median near the mid-point of the carapace, the posterior transverse furrow about twice as far from the median furrow as from the posterior margin of the carapace. Abdomen relatively stout, 1.1 mm. long, about 0.9 mm. wide. Tergites divided, the first weakly so; weakly to moderately developed tergal spurs on anterior five tergites; color and granulations of tergites as in the carapace; setae forming a marginal row except for a pair of lateral setae in tergites six through ten; total setae of tergites one through eleven as follows: 10:10:10-12:10-12:10:14:12-14:12-14:10-14:10:8-10; all setae spine-like, subcylindrical, non-clavate, with three or four very weak terminal and subterminal denticulations; setae short especially in the anterior tergites. Sternites five through eleven divided, the posterior five with sculpturing and coloration as in the tergites, the more anterior sternites lighter in color and less strongly granulate; setae of sternites fairly long, acuminate; fourth sternite weakly divided and with ten to twelve setae spaced between the respiratory stigmata; each half sternite in segments five through nine with six to eight setae; sternites ten and eleven each with only six or eight setae; sternites except the anterior three each with a median pair of conspicuous slit-like lyrifissures and in addition on some sternites one or two pairs of smaller lateral lyrifissures. Pleural membranes marked by numerous wavy striations. Anterior stigmatic plate asetaceous; each posterior plate with one seta.

Chelicera: Base with weak net-like surface markings; flagellum of three apparently entire setae; base with five setae; laminal and interior setae two or three times longer than the basal and subbasal; exterior seta of moderate length; length of chelicera 0.185 mm., width of base 0.12 mm., movable finger 0.155 mm. long. Fixed finger with wide lamina exterior; inner surface of apical tooth with three denticles followed by three retroconical teeth along the inner margin of the finger; serrula interior with the four distal teeth free and with serrate margins, the others fused into a velum. Movable finger relatively stout; apical tooth terminally blunt and with several poorly developed terminal and subterminal cusps; subapical lobe inserted directly at base of apical tooth, conical and acute; galeal seta inserted very close to subapical lobe and base of galea, reaching to level of tip of galea; galea fairly stout, with five or six simple spur-like branches, terminal and subterminal, confined to the distal half of the galea; serrula exterior with eighteen ligulate plates, the proximal two being somewhat longer than the remainder.

Palpus: Moderately slender; surface granular except for fingers of chela; granulations coarser on trochanter and on flexor surfaces of femur and tibia than elsewhere; color reddish-brown to golden, with the hand somewhat darker; setae except those of maxilla and fingers sparse, short, and subterminally paucidentate. Maxilla with very few short and apparently acuminate setae;



color like that of the carapace; two apical setae; length 0.32 mm., width 0.225 mm. Trochanter with a few short, paucidentulate setae on flexor surface; flexor margin evenly convex; extensor surface with two very granular sublateral protuberances; width 0.17 mm., length about 1.6 times the width. Femur without definite pedicle; inner margin almost straight; outer margin mildly convex; setae on both medial and lateral surfaces short, sparse, and very inconspicuous; length 0.56 mm., width 0.163 mm., length 3.45 times the width. Tibia with pedicle almost as long as wide; sculpturing and chaetotaxy as in the femur; inner margin convex, and well set off from the pedicle; outer margin convex with central portion flattened; length 0.495 mm., width 0.197 mm., length 2.5 times the width. Chela from the dorsad with pedicle as long as wide; inner margin of hand convex; outer margin of hand convex but flattened in the central half; entire hand moderately granular, with a few scattered paucidentulate setae; fingers slender, evenly curved; length of chela 0.945 mm., width 0.295 mm., length 3.2 times the width. From the side, the hand is evenly convex on the dorsal margin; ventral margin weakly convex; hand deepest near the center; fixed finger in side view stouter than movable finger and with a concave outer margin but a convex inner margin; movable finger relatively slender, distinctly curved, with a concave inner margin and a convex outer margin; length of hand 0.46 mm.; depth of hand 0.28 mm., being slightly less than the hand width; movable finger 0.50 mm. long, slightly in excess of the length of the hand without the pedicle. Teeth of chelal fingers contiguous, regular, not acute; a conspicuous cusp present and deflected toward the proximal portion of each tooth; teeth of extreme proximal portion of marginal row slightly smaller and less elevated than the distal teeth; fixed finger with between thirty-five and forty teeth arranged along most of the finger margin; movable finger with about forty teeth similar in position and shape to those of the opposing finger; each finger with a lamina defensor. Fixed finger with eight sensory setae: *it* not much distal to mid-point of finger; *et* within the distal one-third of the finger; *eb* and *esb* separated by little more than one areole diameter and located near the base of the finger; *est* midway between *et* and *esb*; *ib* on nearly same level as *esb* and about two areole diameters from *isb*; *ist* a little proximal to level of *est* and slightly nearer to *it* than to *ib*. Movable finger with *t* a little more than two-fifths of finger length from tip; *b* about two areole diameters from *sb* and nearly the same distance from the base of the finger; *st* midway between *sb* and *t*. Nodus ramosus of fixed finger somewhat distal to the level of *it*; of movable finger about two areole diameters distal to the level of *t*.

Legs: Moderately stout; granular; setae, except those of the flexor surface of the tarsi, paucidentulate. First leg with trochanter 0.115 mm. deep, length 1.1 times the depth, extensor surface with two weak protuberances; a few setae, including a long tactile seta, on the flexor surface of the trochanter; pars basalis with few setae, slightly more granular than the trochanter, inner margin evenly convex, length 0.19 mm., depth 0.125 mm.; pars tibialis more coarsely granular than other pedal podomeres, setae sparse, both margins weakly convex, length 0.230 mm., depth 0.105 mm.; tibia stout, flexor margin convex, extensor margin almost straight, setae sparse, setae of extensor surface thick and short

but longer and subacuminate on the flexor surface; tibia 0.251 mm. long, 0.093 mm. deep; tarsus subfusiform, setae (except the distal ones) of the extensor surface subterminally paucidenticate, setae of flexor surface relatively long and acuminate, length 0.258 mm., depth 0.078 mm. Tarsal claws of first leg modified; the medial claw with a heavy basal portion, otherwise much as the claws of other legs; the lateral claw modified by being divided into a fairly stout basal portion and a narrow spine-like terminal part, the two joining at an angle slightly greater than a right angle; near the proximal end of the slender terminal portion of the lateral claw is found on the lateral surface a very small spur while near the center of the terminal portion is located on the medial surface a spur slightly larger than the first; each of these spurs is difficult to see in lateral or medial view and can be seen best when the claw is viewed from above or below. Fourth leg with sculpturing and chaetotaxy much as in the first leg; trochanter 0.133 mm. deep, about 1.75 times as long as deep, flexor margin nearly straight, extensor margin convex but markedly flattened in the proximal half; pars basalis subtriangular, flexor margin with a few relatively long and acuminate setae, length 0.152 mm., depth 0.122 mm.; pars tibialis more coarsely granular than other podomeres, few short and paucidenticate setae, flexor margin almost straight and continuous with the margin of the pars basalis, extensor margin highly arched and evenly convex, length 0.368 mm., depth 0.165 mm.; entire femur 0.460 mm. long, 0.165 mm. deep, about 2.8 times as long as deep; tibia weakly S-shaped, length 0.330 mm., length 3.35 times the depth; tarsus subcylindrical, margins little convex, length 0.326 mm., depth 0.072 mm., length slightly more than 4.5 times the depth; sensory seta of tarsus removed from the base of the podomere by three-fourths of the length of the podomere; terminal claws simple.

Genital complex: Ram's-horn organ present, coxal sacs elongated, thrown into lobes and plications at lateral ends; sclerotic rod present; posterior genital operculum with two transverse rows of about eight acuminate setae in each row; two pairs of setae medially placed on the posterior rim of the genital vestibule; anterior operculum with about twenty acuminate setae in a single transverse row along the anterior margin of the genital pore and a cluster of about thirty irregularly arranged but similar setae anterior to the row; in the vicinity of the pores of the coxal sacs on the fourth legs and to some extent on the inner ends of the coxae of the third legs, there occur numerous closely set, acuminate setae.

*Female*.—In general, similar to the male; body length 1.55-1.9 mm. Carapace 0.63-0.66 mm. long; width varying from slightly greater than the length to 1.1 times the length; ocular breadth 0.35-0.38 mm. Abdomen 0.9-1.1 mm. long; width about 0.85-0.95 mm. Tergites without definite tergal spurs; setae varying from eight to ten in the first tergite to as many as fourteen (occasionally sixteen) in some of the central tergites; tergite eleven with about ten setae; otherwise as in the male. Sternites five through eleven divided; sternite four with ten to fourteen setae; number of setae of other sternites variable, central sternites with from six or seven to as many as ten on each half sternite; sternite ten with four or five setae on each half; otherwise much as in the male. Pleural membranes and chaetotaxy of stigmatic plates as in the opposite sex.

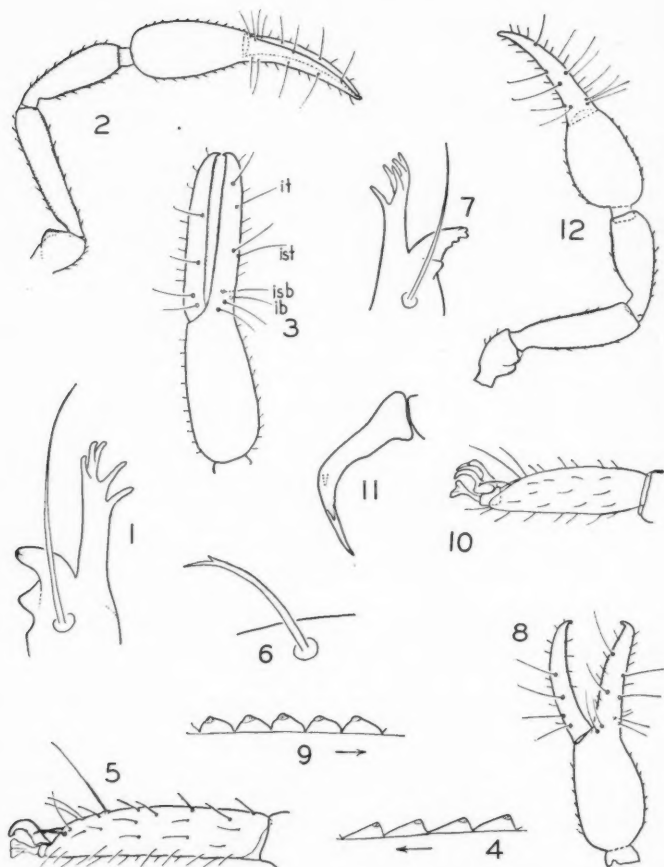
**Chelicera:** Teeth of inner margin of fixed finger variable, reduced to two teeth in one instance, in another instance two small additional rudimentary teeth occur proximal to the regular marginal teeth; apical tooth of movable finger blunt, easily broken, cusps weakly indicated; galea with five or six terminal and subterminal branches; length of chelicera 0.185-0.20 mm., width of base 0.125 mm.; length of movable finger 0.155-0.17 mm.; otherwise as in the opposite sex.

**Palpus:** General characteristics of the palpus as in the male. Maxilla 0.32-0.34 mm. long, width 0.21-0.23 mm., length 1.45 to 1.6 times the width. Trochanter with length of 0.26-0.285 mm., width 0.16-0.18 mm., length 1.55 to 1.65 times the width. Femur with medial margin varying from very weakly concave to weakly convex; outer margin may be slightly flattened in the middle; length of 0.59-0.60 mm., width 0.17-0.175 mm., length 3.45 to 3.55 times the width. Tibia 0.48-0.50 mm. long, 0.19-0.205 mm. wide, length 2.4 to 2.5 times the width. Chela in dorsal view as in the male; length 1.0 mm., width 0.285-0.315 mm., length 3.2 to 3.5 times the width. In lateral view, the hand and fingers are as in the male except the dorsal margin of the hand seems less regularly convex in some individuals; length of hand 0.48-0.49 mm.; depth of hand 0.26-0.285 mm.; length of movable finger 0.53-0.55 mm. Marginal teeth of fingers as in the male. Tactile setae much as in the male; *ist* in some females a little farther removed from *ib* and relatively closer to *it* than in the male holotype; position of *st* somewhat variable in different individuals. Position of *nodus ramosus* in each finger as in the male.

**Legs:** Essentially as in the male except for the tarsus of the first leg. First leg with depth of trochanter 0.10-0.11 mm., length 1.1 to 1.2 times the greatest depth; pars basalis 0.170-0.185 mm. long, depth 0.118-0.125 mm., length about 1.5 times the depth; pars tibialis 0.220-0.230 mm. long, 0.102-0.107 mm. deep, length 2.14 to 2.18 times the depth; tibia 0.228-0.243 mm. long, depth 0.08-0.0835 mm., length 2.82 to 2.92 times the depth; tarsus somewhat narrowed distally, deepest near the proximal third, flexor and extensor margins weakly convex, the extensor less so than the flexor and sometimes almost straight; tarsus 0.27-0.275 mm. long, 0.061 mm. deep; tarsal claws not modified but similar to claws of other legs. Fourth leg with both margins of the trochanter somewhat convex; trochanter 0.121-0.13 mm. deep, length 1.75 to 1.95 times the depth; pars basalis 0.165-0.185 mm. long, 0.12-0.13 mm. deep, length 1.25 to 1.45 times the depth; pars tibialis 0.39 mm. long, 0.156-0.167 mm. deep; entire femur 0.485-0.505 mm. long, 0.156-0.167 mm. deep, length 3.0 to 3.15 times the depth; tibia and tarsus not so stout as in the male; tibia 0.345-0.35 mm. long, 0.094-0.0985 mm. deep, length 3.5 to 3.7 times the depth; tarsus 0.33-0.345 mm. long, 0.0685-0.072 mm. deep, length 4.75 to 4.9 times the depth.

**Genital complex:** Posterior operculum with usually twelve well-spaced acuminate setae arranged in a single row; anterior operculum with five or six, occasionally as many as eight, setae on each side of the genital pore, lateral and anterior to the opening; cribiform plates of median pair smaller than the plates of the lateral pair.

**Type locality.**—A single collection consisting of the male holotype, the



Figs. 1-6. *Hysterochelifer longipalpus*, new species. 1, Galea and end of movable finger of chelicera, female paratype. 2, Dorsal view of palp, female holotype. 3, Lateral view of chela of female paratype. 4, Teeth of fixed finger at level of tactile seta *ct*, female holotype. Arrow points distad. 5, Tarsus of fourth leg, female holotype. 6, Sub-terminal seta of fourth leg, female holotype.

Figs. 7-12. *Hysterochelifer callus*, new species. 7, Galea and apical tooth of movable finger of chelicera, male holotype. 8, Lateral view of chela, male holotype. 9, Teeth of marginal row of fixed finger of chela at level of sensory seta *et*, male holotype. Arrow points distad. 10, Tarsus of first leg, male holotype. 11, Lateral terminal claw of first leg, male holotype. 12, Dorsal view of palp, female allotype.

female allotype, and two female paratypes was taken by Drs. Frison and Mohr on March 17, 1933, from "sand and grass in the dunes area" near Zion, Lake Co., Illinois.

*Remarks.*—*Hysterochelifer callus* is easily separated from most other species of the genus on the basis of length:width ratios of the palpal podomeres and by the length of the finger which is longer than the hand. Our form appears to bear some relationship to *H. fuscipes* (Banks, 1909). Although brevity of the original description makes detailed comparison impossible, *Hysterochelifer callus* may be readily separated from *H. fuscipes* by the finger being noticeably longer than the hand without the pedicle in our form and by the presence of five setae on the base of the chelicera rather than four as reported for *H. fuscipes* by Chamberlin (1923). From *H. geronimoensis* (Chamberlin, 1923) our form may be separated by the stouter femur and tibia, the differently shaped chela, and the narrow finger. Separation of *H. longidactylus* and *H. callus* may be carried out by means of the much stouter chela and femur and the much smaller body size in *H. callus*.

#### DACTYLOCHELIFER COPIOSUS Hoff, 1945

1945. *D. copiosus* Hoff, Trans. Amer. Microsc. Soc., v. 64, p. 53.

The present specimens from Illinois agree favorably with the type individuals from Arkansas. Some differences have been found, however, in the length:width ratios of several of the palpal and pedal podomeres of the male, the palps and legs of Illinois males being slightly stouter but of the same absolute length as the corresponding appendages in males from Arkansas. The differ-

TABLE 2.—Differences in length:width ratios of certain palpal and pedal podomeres of males of *D. copiosus* from Illinois and Arkansas.

|                     | Arkansas | Illinois  |
|---------------------|----------|-----------|
| Palp: Femur .....   | 4.1-4.35 | 3.9-4.25  |
| Tibia .....         | 3.3-3.55 | 3.0-3.3   |
| Chela .....         | 4.0-4.4  | 3.85-4.25 |
| Leg I, tarsus ..... | 3.0-3.2  | 2.7-3.0   |
| Leg IV, tibia ..... | 4.1-4.25 | 3.7-4.0   |

ences do not appear sufficient to justify the erection of even a new subspecies for the Illinois individuals, especially since the females from the two localities appear to be identical.

*Dactylochelifer copiosus* is here reported from eight Illinois collections. Three of these belong to the American Museum of Natural History and were made by Dr. and Mrs. Clarence J. Goodnight: one from Pere Marquette State Park, Jersey Co., and the other two from near Gillespie, Macoupin Co., Illinois. Five collections are from the Illinois State Natural History Survey and include one collection from Pope Co., one from Jackson Co., two from Castle Rock, Ogle Co., and one from Massac Co., Illinois.

Most records of this species are from "ground cover" although one collection was made by C. J. Goodnight while sweeping vegetation with a net.

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## The Behavior and Growth of Young DeKay's Snakes (*Storeria dekayi dekayi*) in Captivity

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Knowledge of the life history and habits of DeKay's snake was limited to field observations until Noble and Clausen (1936), Clausen (1936a) and (1936b), and Noble (1937) presented the results of their extensive laboratory experiments which were supplemented by field observations. Observations on a brood of DeKay's snakes made at Ashland, Ohio are here reported.

A female DeKay's snake, 348 mm. long, gave birth to 16 young on August 4, 1943. One of the young was dead at birth. The remaining 15 were separated from the female and placed in a glass-sided aquarium 50 cm. by 25 cm., the bottom of which was covered with 3 or 4 cm. of damp sand. One-half of the sanded area was covered with moss; the other half contained a small water dish, a food dish, and for hiding places a potsherd and a piece of bark. The water was changed weekly, and fresh food was offered daily except as noted elsewhere. The total weight of the brood and the length of the snakes were taken at frequent intervals until observations were terminated on October 31.

The newly born of DeKay's snakes are active, as noted by several investigators. However, they do not at first seek concealment or form aggregations after the usual manner of the species. Instead, these specimens lie about the terrarium in postures suggestive of the positions assumed in the egg membranes, or slowly explored their environment. The snakes exhibited no fear of the observer except to draw back from a quick motion of any object that passed them closely. They were not disturbed by gentle handling until more than a week old.

The snakes were offered a bean sprout covered with aphids (*Aphis rumicis*) and a dish containing both larvae and adults of flour beetles (*Tribolium castaneum* and *T. confusum*), but none of these insects were taken. The snakes gradually became more restless until, at the age of 4 days, they were climbing to the top of the aquarium. At this time, slugs and small earthworms were taken eagerly from the observer's hand. Subsequently the snakes were maintained on a diet of chopped earthworms supplemented from time to time by a few slugs.

Experimental testing of insects as food was continued. Offerings of imported cabbage worms (*Pieris rapae*), cutworms (noctuid larvae), either whole or particulated, small beetle grubs (Mexican bean beetles, *Epilachna varivestris*, and unidentified scarabeids), ant pupae (the black ant, *Formica subsericea*, and a smaller red species), crickets, and millipeds were ignored by the snakes. Indeed, a small black cricket lived with the serpents from August 15 until October 31.

The young snakes spent most of the daylight hours in concealment after



they were a week old. About 6 p. m. their heads were thrust from their hiding places, and a few of them began to prowl about the cage. Shortly after the food dish was replenished, the snakes left their hiding places and congregated about the food dish. Food was detected apparently both by sight and by scent, as Noble and Clausen (1936) demonstrated experimentally.

The DeKay's snakes usually approached food slowly and tested the prey carefully with the tongue before seizing it. The food was grasped firmly with a little forward thrust of the head. The serpent immediately crawled backward after seizing its prey. Under natural conditions, this prompt retreat would serve to limit as much as possible the withdrawal of earthworm prey into its burrow. While the snake retreated, it lashed its tail rapidly and frequently anchored it about any available object such as a projecting piece of moss. The snakes showed no judgment concerning the size of the animal attacked. Large earthworms made ingestion impossible by swelling the segments immediately in front of the snake's jaws, and by violent writhings which frequently turned the small snakes over.

The snakes fed daily until September 16, but between that date and October 1 their appetite lessened markedly. During October, a small amount of food was consumed, but the snakes exhibited no real eagerness for it. Often a single snake spent 15 minutes over the fresh worms in the food dish before making a selection. Meanwhile, no other serpent approached the food. Simultaneously, their habits of concealment changed. They spent many of the daylight hours in loose aggregates on top of the moss in the cage. This behavior may be likened to snakes sunning themselves on warm, sunny days in October in these latitudes since the terrarium was kept in a heated building.

The brood under observation was weighed weekly as a group, and snakes were measured individually except that only one snake was measured on August 5. It may be seen from the table that the weight of the snakes increased fairly regularly until September 16. The weight obtained on September 2 was relatively low, possibly because the serpents were shedding at the time. The mean length of the snakes increased 29.5 mm. while they were under observation.

The first snake shed on September 1 when it was approximately 3 weeks old. On that day and the following day 6 of the brood shed. The six which shed averaged 7 mm. longer than the 9 which did not. Several more snakes shed between September 22 and September 28. Possibly, some of the snakes shed on both occasions. After shedding, the white ring about the neck, which is a mark of the juvenile DeKay's snake, was not so wide as before, but it remained conspicuous as long as these snakes were observed. Trapido (1944) states that there is a decided dimming of the white area when the young are from 150 to 160 mm. long.

#### DISCUSSION

The brood of snakes observed by us did not attain as great an average length as the first year snakes observed by Noble and Clausen (1936) possibly because those investigators measured their snakes in February after many of

TABLE 1.—Growth of young *Storeria dekayi dekayi* in captivity.

| Date      | Weight  |         | Length |         |                    |
|-----------|---------|---------|--------|---------|--------------------|
|           | Total   | Mean    | Mean   | Range   | Standard deviation |
| (1943)    | (Grams) | (Grams) | (mm.)  | (mm.)   |                    |
| Sept. 9   | 15.6    | 1.04    | 128.8  | 105-148 | 12.3               |
| August 5  | 6.6     | 0.44    | 96 *   | -----   | -----              |
| August 12 | 7.2     | 0.48    | 104.2  | 92-114  | 6.8                |
| August 19 | 8.4     | 0.56    | 110.3  | 95-120  | 6.6                |
| August 26 | 12.2    | 0.82    | 115.3  | 98-129  | 7.0                |
| Sept. 2   | 12.9    | 0.86    | 120.9  | 101-135 | 9.1                |
| Sept. 9   | 15.6    | 1.04    | 128.8  | 105-148 | 12.3               |
| Sept. 16  | 18.0    | 1.20    | 132.7  | 105-150 | 11.2               |
| Oct. 1    | 16.8    | 1.12    | 133.5  | 107-151 | 11.1               |
| Oct. 31†  | 16.2    | 1.16    | 133.7  | 108-154 | 11.5               |

\* Only one specimen measured.

† One snake was found dead October 10, 1934.

them had been in captivity apparently for several weeks. Furthermore, Noble and Clausen report that 6 female snakes observed in nature at Flushing Meadows, Long Island, were all parturient in July while the brood used in these observations was born in August. Since the growing season at Flushing, Long Island, is 204 days long, while the growing season in this vicinity is only 157 days (1941 Yearbook of Agriculture), it is possible that DeKay's snakes are generally parturient at an earlier date in the former locality. Therefore, snakes born on Long Island may have a few more weeks of activity and growth during the first year of life than snakes born in this vicinity.

Our brood of snakes could not be induced to accept as food insects of several kinds. Shields (1929) reports immature snakes which died of starvation in the presence of food, which may have been small insect larvae. Valid records, however, indicate that insects are eaten by at least some members of this species. Whether the acceptance or refusal of insects is an individual idiosyncrasy or a habit which changes with age can not be determined at present.

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- ASHLAND, OHIO.

## Races of *Vireo griseus* in Eastern United States

Thomas D. Burleigh and George H. Lowery, Jr.

Four recent authors, treating essentially the same material, have advanced four separate proposals regarding the pattern of geographical variation in the populations of the White-eyed Vireo (*Vireo griseus*) in the eastern United States. Not one of the four proposals seems to be entirely correct and compatible with the facts demonstrated by the material currently available for study. An adequate series of topotypical and near-topotypical examples of *Vireo g. griseus* from southern Louisiana and the central Gulf coast region is now available for the first time and is the principal basis for the conclusions we have reached.

Ridgway [Bull. U. S. Nat. Mus. 50(3):183-186, 1904] recognized two races in the eastern United States. One race (*V. noveboracensis maynardi*) was considered to range from the Florida Keys northward on the Florida Peninsula to Tarpon Springs on the west coast and Anastasia Island on the east coast. The other race (*V. n. noveboracensis*) was said to range northward from Florida throughout the eastern United States to the Great Plains. Todd (Wilson Bull. 38:222-223, 1926) also recognized two races, a northern and a southern race. The latter was said to extend from South Carolina westward across the Gulf states to Louisiana and southward through Florida and the Florida Keys (thereby including *maynardi*). For this race Todd resurrected the name *Tanagra grisea* Boddaert (type locality: "Louisiana"). Todd considered that the northern race (*V. g. noveboracensis*) occupied all of the eastern United States not included within the range of *V. g. griseus*.

Oberholser (La. Dept. Cons. Bull. 28:499-503, 1938) recognized three races, a northern, and a southern, as well as the south Florida race (*maynardi*) previously accepted by Ridgway. Shortly afterwards Wetmore [Proc. U. S. Nat. Mus. 88(3089):554-555, 1940], in his review of the problem, asserted that in his opinion Ridgway's treatment was most logical. However, we recently submitted our material to Wetmore with the result that he revised his opinion and endorsed (*in litt.*) the conclusions herein advanced.

A fifth worker, John W. Aldrich, also recently examined a large assemblage of specimens, including some of the important Gulf coast material, and independently arrived at the same conclusions reached by us. We appreciate Dr. Aldrich's cooperative spirit in turning over his notes to us when he learned that we were already studying the same problem.

Among Ridgway, Todd, and Oberholser, Todd's conclusions most closely approach our own, the principal difference being that he did not recognize *V. g. maynardi* from extreme southern Florida. Oberholser recognized *maynardi*, but the range given by him for *griseus* is much too extensive. In fact the impetus behind this study was our inability to collate our Gulf coast material with Oberholser's treatment (*loc. cit.*) of Louisiana specimens. Our material

demonstrates that *griseus*, in the Gulf coast region, is confined to the periphery of the coastal plain and hence ranges only a short distance inland. The restriction of *griseus* to the edge of the coastal plain likewise holds in its distribution along the Atlantic coast where it ranges northward to eastern North Carolina. The fact that *griseus* does swing northward along the Atlantic coast is doubtless the cause for some of the disagreement among taxonomists with regard to the present problem, especially where a straight north-south separation of races was attempted.

Another factor which has caused confusion in this as well as other problems involving southern races, is the fact that some northbound individuals of many species are very late in passing through the Gulf coast region of the southern United States. For instance, a series of White-eyed Vireos taken in southern Louisiana during late April and early May, when the species is already nesting in that region, is by no means a sample of the breeding population, but is probably a mixture of migrants and local breeders (for May records of *noveboracensis* in southern Louisiana, cf. Oberholser, *loc. cit.*: 502). Thus, in analyzing Gulf coast breeding populations, one must be cognizant of the possibility that any series is likely to contain a few belated northbound migrants.

Todd (*loc. cit.*) did not consider the birds from southern Florida separable from his series from western Florida. Although we have not seen the Florida material that Todd used and which he described as "... a good series of specimens including ten from Key West ... shot in March ...", we are certain that such a series cannot be accepted as definitely representing the southern Florida breeding population. In March a series of specimens certainly could contain some, if not many, northbound migrants. A specimen (L.S.U.M.Z. no. 3858) before us is illustrative of this fact. It is an extremely brightly-marked, small-billed female, collected at Key Largo on April 3, and is without a doubt an example of the northern race, *noveboracensis*.

Geographical variation in the White-eyed Vireo in eastern United States follows three major trends. Populations from southern Florida and especially the Florida Keys are extremely dull colored and possess a large bill. Populations occupying the coastal plain of the central Gulf coast region from eastern Texas to Georgia and northern Florida, and the Atlantic coast region from southern Georgia to eastern North Carolina are somewhat brighter and have a small bill. Populations from the coastal plain of Virginia northward to New England, westward through the middle and upper Mississippi valley, and southward to the edge of the coastal plain of the Gulf coast region are the brightest yellow on the flanks and more yellowish green above, and also have a small bill. The brightest and most yellowish specimens on the upper parts occupy the interior of the eastern United States away from the coastal plain, from Tennessee northward. The trend in geographical variation, therefore, is from a dull-colored, large-billed population occupying southern Florida, through a somewhat brighter, small-billed form on the coastal plain of the southeastern United States, to a richly-colored, small-billed form of the interior and northeastern United States. The difference between the three forms is, in our opinion, more than sufficient to justify their nomenclatural recognition.

Therefore, Todd, Oberholser, and Wetmore were entirely correct in recognizing the distinction between populations occupying the coastal plain of the Gulf of Mexico and those occurring inland. No difficulty is experienced in separating breeding birds from the two areas, nor likewise in recognizing migrants of the interior race taken on the coastal plain in migration. The problem condenses itself to the application of proper names for the three races and the delineation of their respective ranges. The races may be summarized as follows:

VIREO GRISEUS GRISEUS (Boddaert)

*Tanagra grisea* Boddaert, Table Planches Enluminees, p. 45, 1783 (based on *Tanagra olive* de la Louisiane D'Aubenton, Planches Enluminees, pl. 714, fig. 1).

*Type locality*.—"Louisiana"; restricted to New Orleans, Orleans Parish, Louisiana.

*Distribution*.—Lower coastal plain from eastern Texas to northern Florida and northward along the Atlantic coast to northeastern North Carolina.

*Subspecific characters*.—Upper parts dull yellowish green and in fresh plumage with a gray wash, especially on the neck and upper back; under parts dull white, washed on flanks with pale yellow; size of bill medium.

*Measurements*.—Eleven breeding males from coast region of southern Mississippi: wing, 57.5-63.0 (average, 60.2 mm.); tail, 46.0-49.0 (47.2); exposed culmen 9.1-10.8 (9.8); depth of bill at gonys proper, 3.5-3.8 (3.7); tarsus, 18.0-19.7 (18.8).

*Specimens examined*.—In all, 76: *Louisiana* (New Orleans, Grand Chenier, Timbalier Island, Cameron), 12; *Mississippi* (Gulfport, Biloxi, Saucier, Deer Island), 33; *Texas* (Huntsville), 3; *Georgia* (Blakely, Brunswick, Woodbine, Hephzibah at Brier Creek), 5; *Florida* (Olustee, Fernandina, Amelia Island, Lake Gentry, Port Rickey, Davista), 8; *South Carolina* (Christ Church Parish), 5; *North Carolina* (Fort Macon, Currituck Sound, Rockingham, Clinton, Smith Island, South Port, New River at Snead's Ferry, Roseboro), 10.

*Remarks*.—The race *griseus* does not extend far inland, either on the Gulf coast or in the Atlantic until the coast of Virginia is reached. John W. Aldrich informs us (*in litt.*) that the series from Washington, D. C., region is somewhat intermediate, but that most of the specimens are closer to *noveboracensis*. In Louisiana both *griseus* and *noveboracensis* occur as breeding birds; but again *griseus* does not range far inland. Oberholser (*loc. cit.*) called all Louisiana breeding birds *griseus*, but at that time he did not have the material now available to us. The breeding population at Baton Rouge is definitely referable to *noveboracensis*. That an occasional specimen is slightly duller than the average for that race is not surprising in view of the proximity of Baton Rouge to the Gulf coast (in one direction, seventy miles). Similarly, material from southern Mississippi shows that specimens taken at Saucier (twenty miles inland) are not quite as dull colored as are those taken on or near the coast. Four out of five specimens from near Charleston, South Carolina, are typical *griseus*, where-

as the fifth specimen has a large bill; this might be regarded as a tendency for that population to vary toward *maynardi*.

The occurrence of two races in Louisiana as breeding populations makes it advisable to restrict the type locality of *griseus* to New Orleans; specimens from that place are typical of the race.

VIREO GRISEUS MAYNARDI Brewster

*Vireo noveboracensis maynardi* Brewster, Auk 4:148, 1887.

*Type locality*.—Key West, Florida.

*Distribution*.—Southern Florida from the Keys northward to Anastasia Island on the east coast and Tarpon Springs on the west.

*Subspecific characters*.—Upper parts duller than in *griseus*; yellow of flanks and sides paler; bill large.

*Measurements*.—Ten breeding males from the Florida Keys: total length, 58.5-62.4 (average, 60.0 mm.); tail 46.5-51.5 (48.8); exposed culmen, 10.3-11.2 (10.9); depth of bill at gonys proper, 4.0-4.6 (4.3); tarsus, 18.4-19.9 (19.2).

*Specimens examined*.—In all, 15: Florida (Key Largo, Key West, Royal Palm Hammock, Anastasia Island, Caxambas).

*Remarks*.—Although this race apparently reaches its maximum development on the Florida Keys, population samples from the lower half of the Florida Peninsula are close, if not indistinguishable, from specimens from the Keys. This has already been shown by Scott (Auk, 1890:15-16 and 312) and Ridgway (1904:186).

VIREO GRISEUS NOVEBORACENSIS (Gmelin)

*Muscicapa noveboracensis* Gmelin, Systema Naturae 1(2):947, 1789 (based on "Green Flycatcher" Pennant, Arctic Zoology 2:389).

*Type locality*.—New York.

*Distribution*.—Interior of eastern United States from the coastal plain of eastern Virginia northward to southern New England, westward to the Great Plains and southward to central eastern Texas and across the Gulf states (exclusive of the coastal plain) in central northern Louisiana, Mississippi, Alabama, and Georgia, to western North Carolina.

*Subspecific characters*.—The brightest of all the races herein considered; upper parts rich yellowish green; sides and flanks bright yellow; eye-ring, lores, and frontal region extensively and richly yellow; bill small.

*Measurements*.—Eleven breeding males from Tennessee: total length 60.0-63.1 (average, 61.3 mm.); tail 47.0-50.5 (48.0); exposed culmen, 9.4-10.5 (10.0); depth of bill at gonys proper, 3.6-4.0 (3.8); tarsus, 18.7-20.4 (19.2).

*Specimens examined*.—In all, 99: New York (Shelter Island), 1; Virginia (Alexandria), 1; North Carolina (Asheville), 1; Tennessee (Maynardville, Norris, Memphis, Germantown, Lucy, Egypt, Cordova), 21; Mississippi

(Rosedale), 1; *Louisiana* (Baton Rouge, Baines, Erwinville, Baywood, St. Francisville, Magnolia Crossing), 41; *Georgia* (Athens), 5. From within the range of *griseus* and *maynardi*, specimens of migrant and winter resident *noveboracensis* have been examined as follows: *Mississippi* (Saucier, Gulfport, Biloxi, Horn Island, Deer Island, Cat Island), 24; *Louisiana* (New Orleans, Cameron), 3; *Florida* (Key Largo), 1.

*Remarks.*—As previously noted, this race reaches its maximum development in the eastern part of the Mississippi valley from Tennessee northward. However, specimens from central southern Louisiana (Baton Rouge), northern Georgia (Athens), and western North Carolina (Asheville), are much brighter in fresh plumage than comparable specimens of *griseus*, and are therefore referred to *noveboracensis*.

For the loan of comparative material and for helpful suggestions we wish to thank George M. Sutton and the Cornell University Laboratory of Ornithology; Josselyn Van Tyne and the University of Michigan Museum of Zoology; Alexander Wetmore and the United States National Museum; John W. Aldrich and the United States Fish and Wildlife Service. Austin W. Burdick and Robert Tucker of Louisiana State University assisted in obtaining additional fresh material from critical areas.

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## Longevity of the Short-tailed Shrew

Oliver P. Pearson

For many years it has been suspected that shrews survive only one breeding season. Most of the reports on this subject have dealt with the genus *Sorex*, which includes the Common and Lesser shrews of Europe as well as the long-tailed shrews of North America, but the American short-tailed shrews, *Blarina* and *Cryptotis*, have been suspected of being equally short-lived. Some recent authors have suggested that meadow mice, deer mice, and other small rodents also have surprisingly short life spans (Baker and Ranson, 1933; Burt, 1940; Hamilton, 1937, 1941, 1942).

The belief that all sexually mature shrews die after their first breeding season is based almost entirely on the apparent absence of adults among shrews collected during the late autumn and winter. The entire problem of longevity of shrews, therefore, depends upon the ability of the investigator to estimate the age of a shrew, and upon ability to determine whether a shrew has been in breeding condition at some previous date, perhaps several months before capture.

Adams (1910, and in Barrett-Hamilton, 1911), studying *Sorex araneus* and *S. minutus*, estimated age by the condition of the reproductive organs, the presence or absence of scars on the tail and feet, and length of the body. Middleton (1931) and Brambell (1935) used body-weight for determining age in *S. araneus*, as did Brambell and Hall (1937) when studying *S. minutus*. Hamilton (1940) used body-weight as well as condition of the tail and teeth in *S. fumeus*. Each of these investigators concluded that shrews do not survive beyond the summer or autumn of their second year, after one season of breeding, although of 451 females examined by Brambell, one parous individual had survived until March.

Some of the methods these investigators have used for determining age are open to question; at least, they should not be relied upon until more is known about them. The condition of the tail and feet, for example, provide only a clue at best, not a reliable index of age. Age determined by the condition of the reproductive organs is also of doubtful reliability, because little is known about what appearance these organs would have in old individuals that might survive until the second winter or spring. The organs of an adult may regress in size after the breeding season to such an extent that they are indistinguishable from those of immature individuals. The presence or absence of placental scars is not a reliable indicator of past reproductive history in females of *Blarina*, and may not be in the other genera. Determination of age by body-weight is also not above question, because it is possible that many adults lose weight after the breeding season. Middleton (1931) states that a definite loss of weight does occur among all shrews in the autumn. Growth is then resumed in the spring. Even Brambell (1935), who appears to have complete faith in

the determination of age by body-weight while he is discussing duration of life of *S. araneus*, evidently abandons this belief without explanation, for some of his breeding males and parous females have weights approximating those of the group which he considers to be young. He mysteriously assumes that these small breeders are old adults and concludes that the young do not breed in their first season.

In contrast to the evidence given above, there is only one published record of over-winter survival of shrews after breeding. Montagu (1922) records an old "grizzled" specimen, caught June 19, in which the teeth were "almost completely worn away."

#### Determination of Age in *Blarina*

In this paper I shall consider only *Blarina brevicauda*, the species with which I am most familiar. The specimens studied were caught in Maryland, Pennsylvania, New York, and Massachusetts. According to Bole and Moulthrop (1942), this geographical range includes two subspecies, *B. b. kirtlandi* and *B. b. talpoides*.

Shrews referred to as "adult" or "mature" are those in breeding condition, or those that have at one time been in breeding condition. The term "old" will be applied to those that have survived one winter, and "young" to those that have not yet experienced a winter. Since Short-tailed Shrews born in the spring sometimes become sexually mature when only a few months old, it is possible to have "young adult" or "young mature" individuals.

It is difficult to determine the age of *Blarina* by size, for many of the young become as large as adults within a few weeks after they have left the nest. The old are probably significantly longer on the average than the young, but the overlap is so great that length cannot be relied upon to separate them. Weight also is unreliable, not only because the young grow so rapidly, but because the weight of an individual varies so much from day to day. To illustrate the change that can occur even in a short time, records are given below of two wild, marked individuals that were weighed, released, and recaptured.

|    |             | Time       | Weight     |
|----|-------------|------------|------------|
| I  | September 4 | 10:45 p.m. | 15.3 grams |
|    | September 5 | 7:15 a.m.  | 17.4 grams |
|    | September 5 | 9:30 p.m.  | 16.6 grams |
| II | September 4 | 5:30 p.m.  | 16.4 grams |
|    | September 5 | 7:30 a.m.  | 14.6 grams |

Captive shrews normally weighing nearly 20 grams have wasted to only 12 grams when in poor health.

The general condition of the pelage and the bareness and degree of scarring of the tail aid in estimating age, but they are not sufficiently reliable to separate old from young without recourse to other characters.

The sex organs become greatly enlarged when *Blarina* comes into breeding condition, but they regress in the autumn after the breeding season. As in *Sorex*, it is not known whether the reproductive tract of an adult *Blarina* in

winter can be distinguished with certainty from that of an immature individual trapped at the same time. Uterine scars are sometimes, but not always, present after parturition, and may last more than four months in some cases (Pearson, 1944). When present they demonstrate sexual maturity; when absent, immaturity cannot be assumed. Consequently, they are of only limited use in judging age and maturity of an individual.

The degree of tooth-wear is a reliable indicator of the age of many mammals, and it seems to be satisfactory for estimating the age of *Blarina*. Hamilton (1940) shows photographs of four distinct degrees of tooth-wear in specimens of *Sorex fumeus*, and states that they represent four different ages. The rate of tooth-wear in an omnivorous animal such as the shrew would be expected to vary depending upon the type of food available. The teeth of an individual existing largely on grit-filled earthworms might become worn more rapidly than those of one eating food that was less abrasive. Captive individuals that have been fed on soft food always show less tooth-wear than wild shrews of similar age. But in spite of these difficulties, the degree of tooth-wear appears to be the best indicator of age in shrews; the satisfactory graph which is obtained when the degree of tooth-wear is plotted against the date of death (fig. 1) inspires confidence in this method of determining age.

The degree of tooth-wear of the shrews represented in figure 1 was estimated by comparing the teeth of each specimen with those of a numbered series of skulls chosen to include a complete range of tooth-wear. Each increase of one number represented an easily noticeable increase in wear (see fig. 4). The skulls were examined with a dissecting microscope, and the teeth in an upper and a lower jaw were compared separately with the standard series. Both jaws could usually be assigned the same wear-number, but when differences occurred the two values were averaged.<sup>1</sup>

It may be seen from figure 1 that the shrew population from May until November can be divided, with only a few exceptions, into two age groups which differ by about four tooth-wear numbers. Young shrews about one month old first appear in numbers in May and have a tooth-wear number of one; a year later the tooth-wear number has reached about five. A dotted line has been drawn on the chart to trace the average tooth-wear of these early-born young for about 18 months, beginning in May. The line approaches seven (extreme tooth-wear) in the autumn of the second year, when these individuals would be about 19 months old. The greatest degree of tooth-wear encountered was seven and one-half; any animals older than this would be practically toothless. It is extremely unlikely, therefore, that any wild shrews survive more than two years.

Flower (1931) states:

When the teeth of a mammal, in its wild free state, become useless for procuring or biting food, the end of the animal must be death from starvation, unless it falls a victim to some other animal first or meets its death by some other accident occasioned

<sup>1</sup> Many of the skulls examined were in the collection of the Academy of Natural Sciences of Philadelphia. I am grateful for permission to study these specimens.

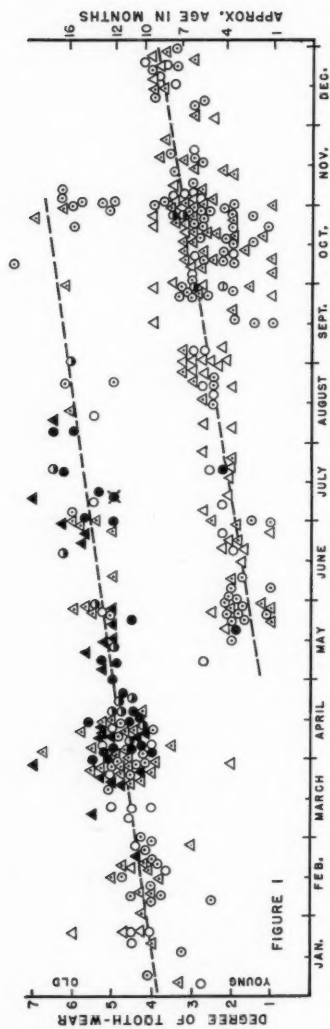


Fig. 1. Degree of tooth-wear of specimens of *Blarina* trapped throughout the year. Compiled from examination of 142 skulls in my collection, and 196 Pennsylvania and New Jersey specimens in the collection of the Academy of Natural Sciences of Philadelphia. Shrews that had been captive more than one month were not used. A rough estimate of age is given at the right-hand margin.

- Non-pregnant female, apparently non-parous.
- Pregnant female.
- ◐ Lactating female, or female with placental scars.
- ◑ Shrew marked RM5RP5, recaptured after one year.
- ▲ Male in breeding condition.
- △ Male not in breeding condition.
- ◔ Male museum specimen. Condition of reproductive organs not recorded.
- ◕ Female museum specimen. Condition of reproductive organs not recorded.

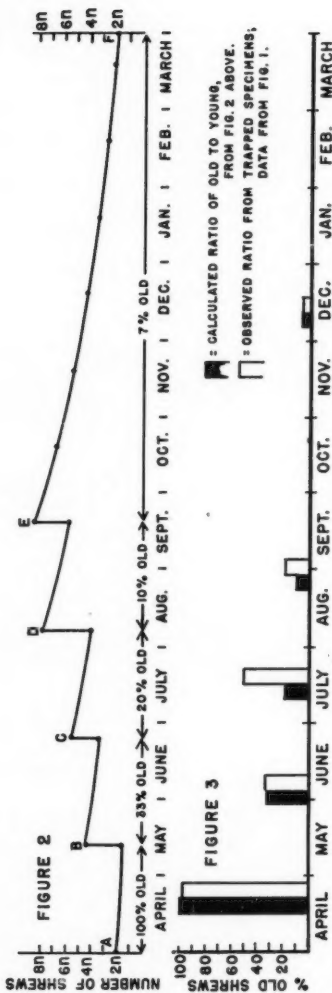


Fig. 2. Theoretical changes in the population resulting from the mating of  $n$  pairs of shrews on April 1; based on assumptions described in the text. The expected ratio of old to young shrews following each period of increase is given along the time axis. A,  $N$  pairs of shrews copulate. B, First litter of 4 weaned by the surviving females. Females breed again. C, Second litter weaned. Old females and one-half the surviving young females of the first litter breed. D, Third litter weaned by surviving old females and first litter by surviving bred young of first litter. All these parous females breed again. E, Fourth litter weaned by surviving old females, and second litter weaned by the surviving bred young. No further breeding. F, Population returns to original number at beginning of the breeding season.

Fig. 3. Comparison of the calculated and observed ratios of old to young shrews.

by its enfeebled condition. Thus the potential length of life of most existing mammals appears to be dependent, with certain important exceptions, on the duration of the teeth.

This observation is probably applicable to the shrew, but, as will be pointed out below, the potential maximum age of shrews is seldom approached because of the extremely high death rate that this prolific species suffers.

Although none of the shrews represented in figure 1 appears to be fully two years old, two specimens apparently had survived two winters. They are the oldest individuals shown in March and April. They were probably born in the late summer two years before, and were probably entering their second breeding season. The March specimen was a male in breeding condition; the April male was a museum specimen with no record of the reproductive organs.

It may be seen from figure 1 that females only a few months old are capable of breeding in their first summer, for both pregnant and parous shrews

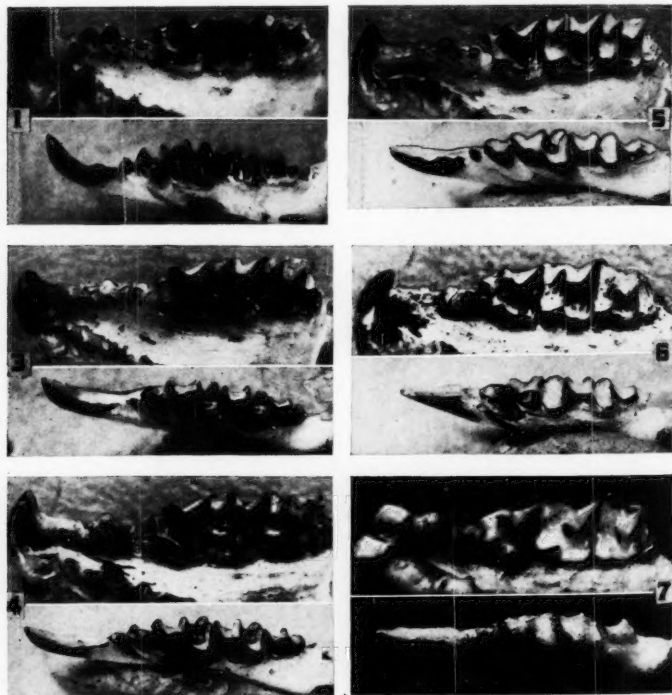


Fig. 4. Upper left and lower left tooth rows of *Blarina* showing six of the seven degrees of tooth-wear. The extent of wear of the pigmented cusps of the upper molars is especially convenient and reliable for determining age.

are represented among the young specimens. There appears to be no reason why these females do not survive the winter and breed again during a second season. No young, wild males, however, were in breeding condition, in spite of the fact that males born in captivity bred when only 83 days old.

### The Age Composition of the Population Calculated from Estimated Fertility

An estimate of the expected ratio of mature to immature shrews can be established for any month if the fertility and reproductive habits are known; figure 2 summarizes an attempt to do this for *Blarina*. Observations on fertility already published (Pearson, 1944) have been used with certain modifications.

It is clear that, on the average, for every pair of shrews existing at the beginning of the breeding season in the spring, no matter how prolific they and their offspring have been during the spring and summer, only one pair will remain alive at the beginning of the next breeding season. Otherwise the total population of the species would increase or decrease alarmingly. There is no evidence that, except for short cycles lasting only a few years, the shrew population is unstable. Figure 2 traces the theoretical reproductive activity of  $n$  pairs of shrews from the day of mating in a given year, through four periods of increase; meanwhile a constant death rate is continuously subtracted until  $n$  pairs remain on the first day of the breeding season one year later. I have assumed that the original females were capable of weaning four litters of four (half males, half females) if they survived long enough to do so, and that one-half the surviving females of the first litter could wean two litters of four. This appears to be very great fertility, but it must be remembered that the mature females are gradually dying off during the entire breeding season with the result that only one-quarter of the original females survive until they wean their fourth litter. Full allowance is made for the fact that some females would die between mating and weaning with consequent death to their young. Young are not considered as additions to the population until they have been weaned. Another assumption made in compiling figure 2 is that the forces of the environment act equally upon shrews of all ages after weaning, so that the death rates of weaned young and of old shrews were the same.

The death rate was fixed by trial and error at a level that would balance the assumed rate of increase and reduce the population to exactly  $2n$  at the beginning of the second breeding season. It was felt that under natural conditions the number of shrews dying from predation, disease, and other causes would be proportional to the number of shrews present in the population, and that the effect of the mortality rate on the population could be duplicated by subtracting a certain percentage of the population each month. This is undoubtedly an over-simplification of population reduction under natural conditions, and it obviously fails in sparse populations that are not reproducing at all. It appears to be satisfactory for the present problem, however, because many of the changes that occur in a wild population are duplicated. For example, it leads to a peak autumnal population four times as large as the spring minimum;



this agrees with my impression gained from trapping. Hamilton (1942), in discussing the common small mammals of New York State (including *Blarina*), also states that catches in the fall may be two to five times greater than in the spring. The death rate, or rate of attrition that balanced the shrew population under the conditions assumed above, was 20 percent per month.

The calculations summarized in figure 2 indicate that only 1 shrew out of every 14 (7 percent) caught in the autumn could be expected to be one that had survived the preceding winter, and therefore was one or more years old. It is clear that the autumnal scarcity of old shrews that has been noted by many naturalists can be partly accounted for by natural decimation and by "dilution" of the old with many young. The above degree of scarcity can be accounted for without assuming a higher death rate among the old.

#### The Age Composition of the Population Determined from Trapped Specimens

In contrast to figure 2, which was based upon the balance between estimated rates of fertility and attrition, figure 1 shows the actual distribution of age groups (age determination by tooth-wear) among trapped specimens. From figure 1 the proportion of old to young shrews for any period can be calculated. For the period from October through March, the proportion of old to young shrews was 11 to 184, or 6 percent. From January through March, 3 percent of all those examined were old shrews. These values are in fair agreement with the theoretical value, 7 percent, given in figure 2. Indeed, the calculated and observed ratios of old to young agree fairly well throughout the year (see fig. 3) except during the mid-summer when an unexpectedly large proportion of old shrews was trapped. This difference might be corrected by assuming that there was a higher death rate for the very young, weaned shrews.

#### Survival Determined by Marking and Retrapping Shrews

During the summers of 1939, 1940, and 1941, 83 Short-tailed Shrews were captured, marked, and released at the place of capture. Twenty-four others were dead or dying in the traps, in spite of the fact that the traps were almost always visited at intervals of less than 6 hours. Many specimens were in a weakened condition, but were released nevertheless; some of these undoubtedly perished a short time afterwards. The shrews were caught in box or cage traps on three small plots in Philadelphia. One plot was selected for its convenient location, the other two because they appeared to be excellent shrew habitats. The three plots were within a quarter of a mile of each other, but were separated by roads and other inhospitable terrain so that the shrew populations did not mingle. The traps covered an area of about one acre on each of the three plots, and they were set as nearly as possible at the same sites in successive years. On the three plots there were approximately 20, 30, and 60 trap-sites, respectively.

The shrews were marked by cutting a different digit or a different combination of digits off of each individual. This method has been used by Blair (1940) for shrews, and by other workers studying small mammals. Records

were kept to show which digits were cut off. For example, the notation 'RM2LP4' would mean that the second digit of the right manus and the fourth digit of the left pes were amputated. Toe-clipping is not entirely reliable, however. Digits had been lost by 3 of 107 specimens of *Blarina* selected at random from the collection of the Academy of Natural Sciences of Philadelphia. One digit had been lost from a front foot in one case, and two adjacent digits were missing from a front foot in each of the other cases. Further evidence that toe-marking of shrews cannot be relied upon completely was provided by two of the shrews encountered on the experimental plots. One of these had lost digits on both front feet through natural causes, in addition to the digits that had been amputated for identification. The other shrew lacked the fourth digit of the right foot when caught only 150 feet from where a similarly-marked shrew had been released three years before. Because the tooth-wear of the second shrew indicated an age of only about one year, I have assumed that it was an impostor that had lost the corresponding digit through natural causes. A mistake in recording is, of course, also possible.

No evidence was obtained that cutting off digits lessened the likelihood of survival. Twenty-nine shrews were recaptured a few days or weeks after they were first marked, despite my efforts to avoid recaptures in the same season. Some were caught as many as six times. The ordeal of being captured undoubtedly lowered the chance of survival, and therefore, the percent of shrews that survived until the next year under the conditions of the experiment was probably smaller than it would have been under natural conditions. In addition, the percent of shrews that were recaptured a second year was probably less than the percent that actually survived, because some may have wandered away from the experimental areas, or may have been still living on the trapped plots, but failed to enter the traps in the second summer. The number recaptured must, therefore, be considered a low estimate of those that survived.

Results of the marking and retrapping experience are summarized in tables 1 and 2.

TABLE 1.—Results from marking and retrapping shrews.

| Year             | No.<br>caught | No.<br>released | No. recaptured<br>same<br>summer | No. recaptured<br>following<br>summer | No. recaptured<br>2 summers<br>later |
|------------------|---------------|-----------------|----------------------------------|---------------------------------------|--------------------------------------|
| 1939             |               |                 |                                  |                                       |                                      |
| July 13-Sept. 14 | 54            | 40              | 22                               | 2                                     | 0                                    |
| 1940             |               |                 |                                  |                                       |                                      |
| July 10-Sept. 18 | 32            | 27              | 7                                | 2                                     | 0                                    |
| 1941             |               |                 |                                  |                                       |                                      |
| June 30-Sept. 1  | 21            | 16*             | 0                                | 0                                     | ..                                   |
| 1942             |               |                 |                                  |                                       |                                      |
| May 10           | 3             | 0               | ..                               | ..                                    | ..                                   |
| Totals .....     | 110           | 83*<br>(67)     | 29                               | 4                                     | 0                                    |

\* It is felt that trapping only part of one day in 1942 did not provide an adequate opportunity for recapturing any of the 16 shrews released in 1941. The exclusion of these 16 left 67 marked, released shrews eligible for recapture. Four were recaptured; therefore, at least 6 percent of the marked shrews survived until the next summer.

TABLE 2.—Records of the four shrews that were recaptured in a second season.

| Number | 1939      | Dates and places of capture<br>1940   | 1941  | 1942  | Minimum<br>age at 2nd<br>capture |
|--------|-----------|---|---|-------|----------------------------------|
| LP5    | July 17   | July 26,<br>130 feet west.  | .....   | ..... | 400 days                         |
| LM5RP4 | August 24 | July 12*,<br>30 feet west.  | .....   | ..... | 348 days                         |
| LM2LP5 |           | July 11, very big.<br>August 15, 120 feet<br>south, 23.4 gms.<br>Sept. 12, 36 feet east,<br>19.1 gms. | July 10, 130 ft. west.<br>Large, fur sparse and<br>worn.              | ..... | 389 days                         |
| RM5RP5 |           | July 11   | July 10, 20 ft. north,<br>19.6 gms., pregnant,<br>tooth-wear index 5. | ..... | 389 days                         |

The place of subsequent capture of each animal is given in relation to the point where that animal was first caught. The minimum age is based on the assumption that the shrews must have been at least 25 days old when first trapped.

\* When recaptured, digits LM3, 5, RM1, 2, RP4 were missing. No other shrew can be fitted into this formula, and it is extremely unlikely that an unmarked shrew would lose digits on three feet through natural causes.

It has been pointed out in an earlier part of this paper that the fertility (and consequently the "turnover") of shrews each year is so great that one cannot expect many to survive until a second season. After making certain assumptions, it was calculated that not more than 7 percent of a population could be expected to survive from one year until the next. The number that was actually recaptured one year later on the experimental plots was 6 percent.

Unfortunately, the trapping was not carried out in the spring of each year before the young were born, because then it could have been assumed that each shrew caught was a mature adult. Since trapping was done in the summer, one could seldom be certain whether the animals released were young or old. Of the four shrews recaptured in a second season, the age of only one of them could be determined, and that was because she died in the trap when recaptured in her second season. Consequently, her skull was available for careful examination of the teeth. The other shrews that were recaptured in a second season were released in the hope that they could be recaptured in a third year.

The individual (RM5RP5) that died when recaptured on July 10 was a pregnant female. Almost one year had elapsed since her first capture. Her tooth-wear number (5) indicates that she was about one year old (see fig. 1); so she was probably only a month or two old when first captured.

One of the other recaptured specimens was very large when first caught on July 11, suggesting that it had already survived one winter, but this cannot be assumed, since weight is not a reliable indicator of age. It is possible that a young shrew might have reached a comparable size by this time. If this individual had survived two winters, it would have been about 21 months old when last caught.

### Survival of Deer Mice

It is interesting to compare the percent of recapture of shrews with the percent of recapture of deer mice, a species in which the old individuals have only recently been suspected of dying off each year. The mouse-trapping reported here was carried out at the same time, place, and under the same circumstances as the shrew-trapping; in fact, the mice were by-products of the trap lines set for the shrews. Forty-six deer mice, *Peromyscus leucopus noveboracensis*, were marked by clipping toes in 1939, and 23 in 1940. Trapping was continued in 1941, but no additional specimens were marked. Of these 69 that were potentially eligible for recapture, only 3 (4 percent) were caught in the following year. Each of these three had been marked in August, 1939; one was recaptured in July, 1940 (330 days later), and two in September, 1940 (390, 384 days later).

Burt (1940) studied marked deer mice in Michigan. He reported that in one wood-lot 26 mice were marked during one August, and only one (4 percent) remained the following August. In his table 11, records are also given of 23 mice captured in June, of which 3 (13 percent) were recaptured 11 months later.

In view of the numerous possibilities for error that are present when determining survival by trapping, and in view of the small numbers of mice and shrews that have been marked, it cannot be said that any appreciable difference in survival rate of shrews and mice has been demonstrated. However, since deer mice are more fertile than shrews, a higher death rate, and consequently a lower percent of survival, would be expected among mice.

Making use of Burt's data (1940) on the fertility of deer mice, I have calculated the "expected" ratio of old to young mice at the end of the breeding season to be 4 percent. This value was computed in the same manner as the calculations for *Blarina* (which gave a value of 7 percent) that were summarized in figure 2. Again it was assumed that the population returned to the same level before the beginning of each breeding season, and that there was an equal death rate of old and weaned young animals. Death of 24 percent of the population each month would be necessary to balance the deer mouse population under the conditions assumed. This compares with an attrition of 20 percent per month necessary to balance the less fertile shrew population.

Blair (1941) has reported the percent of old deer mice among a population of *Peromyscus maniculatus gracilis* residing in a Michigan wood-lot between August 23 and September 22. Basing his determinations of age on considerable experience in handling deer mice of known ages, he concluded that 6.1 percent of the resident population were old survivors from the previous year. This is in good agreement with the observed and calculated ratios (4 percent) given above for *P. leucopus*. It is not unlikely that a few late litters would have lowered the 6.1 percent somewhat if trapping had been carried out a few weeks later, thus making the agreement even closer.

Hamilton (1942) states that deer mice probably die "of senility or some other cause after they have passed through a single breeding season." Burt

(1940), however, believes that few, if any, of these mice ever die of old age. He states that most are probably eliminated by predators or die of some other cause before they reach the age of one year, and that, since the probability of finding the bodies is remote, it is difficult to obtain data on their natural mortality.

Baker and Ranson (1933) and Hamilton (1937, 1941), relying upon body-weight for determining age, state that mature meadow mice (*Microtus*) seldom survive the winter. Baker and Ranson state:

During the winter the species is represented, so far as males are concerned, only by small, non-fecund individuals less than a year old. So far as we know, this is a phenomenon which has never been described in any mammal, though, of course, many insects over-winter in the larval condition. . . . The majority of the mature females also die in the autumn or early winter.

The authors suggest no cause of death. Hamilton attributes the short life span to early sexual maturity, heavy reproductive burden, and incessant activity. These are speculations not easily proved, and they lead too easily to the assumption that death is due to some nebulous cause such as "old age."

The trapping records given above suggest that the life span and the factors determining longevity are similar in deer mice and short-tailed shrews. The similarity probably also extends to meadow mice, although the persistently growing molar dentition of *Microtus* is a fundamental difference that cannot be overlooked. The limitation imposed on longevity in the shrew by tooth-wear is more potential than actual, however, for few shrews survive until the teeth are badly worn.

#### Longevity in Captivity

Flower (1931) published records of the longevity of several species of Insectivora in captivity. A tree shrew, *Tupaia tana*, survived for 2 years and 4 months, and two species of *Crocodyra* lived 14 and 15 months in captivity. In regard to these short life spans, he remarked: "This does not prove that Insectivora are short-lived—it shows the difficulties of providing for their natural wants under artificial conditions." Barrett-Hamilton (1911) told of one water shrew, *Neomys*, that survived 8 months in captivity, but in regard to *Sorex araneus* he stated that he was unaware of their having survived capture longer than a few months.

I have kept four wild-caught specimens of *Blarina* for periods ranging from 9 to 12 months. Each of these individuals (two males and two females) was caught in the spring before young had appeared; therefore, several months may be added to the life span of each. When this is done, the records show that each must have been at least 15 months old at death. Another wild-caught female, born in 1942, had a litter in captivity in 1943, underwent an ovariectomy shortly afterwards, and died of a large tumor in March, 1945. She was at least 30 months old. Another female caught October 5, 1943, had considerable mammary tissue and one placental scar in the uterus, showing that she had borne at least one litter. She failed to mate the first part of the 1944 breeding season and died in July. These last two cases demonstrate that parous

females are capable of surviving at least one winter after they have borne young.

Two male littermates born on May 18, 1942, are noteworthy. One died of starvation on October 26, 1944, at the age of 29 months; the other died on March 7, 1945, probably of a heavy nematode infection, at more than 33 months of age. He was entering his fourth breeding season.

Deer mice and meadow mice are similar to the shrew in that they too can live two or more years in captivity but are short-lived in the wild. The teeth of shrews wear down more rapidly in the wild than in captivity, and this probably limits the age of wild shrews to about two years. But this limitation is more potential than actual, for only a small fraction of the population survives until the teeth are badly worn. The teeth of meadow mice never wear out, and yet their life span in the wild is checked apparently as effectively as that of the shrew.

#### Discussion

The ultimate fate of the individuals that do reach old age is unknown. Adams (1910) and Hamilton (1940), writing of *Sorex*, have claimed that old age itself is the cause of death, and they suggest without proof that these old individuals are the ones that are found dead in the autumn. This was suspected even in the time of Pliny, who states in Book 8 of his *Natural History*, that when the parent shrews are exhausted by old age, they are fed by the young with remarkable affection, and that their old age comes to its end during the "winter repose." This explanation is, of course, incorrect, because shrews do not hibernate, but it reveals that mortality of shrews interested the early naturalists.

The occurrence of dead shrews in the wild has been noted by many authors, one of whom refers to it as an "autumn epidemic." Most of these reports have come from England, where the two species of *Sorex*, as well as the water shrew, *Neomys*, are subject to this mysterious mortality, and where shrews, both living and dead, seem to be encountered in greater numbers than in this country. *Blarina*, *Cryptotis*, and the American species of *Sorex*, however, are also found dead frequently (Rhoads, 1903; Evermann and Clark, 1911; Cory, 1912; and others).

As early as 1831, Knapp wrote (p. 103) concerning *Sorex araneus*:

The common shrew, in spring and summer, is ordinarily in motion even during the day . . . which occasions the destruction of numbers by cats, and other prowling animals; and thus we find them strewn in our paths, by gateways, and in our garden walks, dropped by these animals in their progress. It was once thought that some periodical disease occasioned this mortality of the species; but I think we may now conclude that violence alone is the cause of their destruction in these instances.

Many later investigators have not been content with this explanation, for in many cases they have not been able to find any cause of death when they dissected the shrew carcasses. Tomes (quoted by Barrett-Hamilton, p. 104) states that both sexes and all ages are affected. Adams (1910) reports that although carcasses are found most frequently in the autumn, they may be found at any season. Hamilton (1931) notes that more might be found in the autumn because they would be seen more easily in the open woods. It is



also a fact that shrews are more abundant in the autumn than at any other time of year, and consequently more would be expected to die at that season. Their death has been ascribed to various causes. These have been listed below with references to the papers in which they are discussed.

1. Hunger (Millais, 1904; Adams, 1910).
2. Thirst (Adams, 1910).
3. Cold (Adams, 1910; Soper, 1942).
4. Predation (Many authors). Mammalian predators find shrews unpalatable because of the scent glands, and consequently discard them uneaten. Barrett-Hamilton (1911) also suggests that the extremely rapid putrefaction of shrew carcasses causes them to be left uneaten in many cases. All of the shrews that I have found dead (1 *Cryptotis* and a half-dozen *Blarina*) had been killed by predators.
5. Increase of internal parasites in autumn (Hamilton, 1931).
6. Intraspecific combat (Millais, 1904; Adams, 1910).
7. Fear (Aflalo, 1898).
8. Thunder (Millais, 1904; Barrett-Hamilton, 1911).
9. Crossing paths used by man. The statement is made in Book 8 of Pliny's *Natural History* that shrews die if they cross the track of a wheel. Millais (1904) reported that a similar superstition still existed both in Europe and among the natives of Uganda.
10. Old age (Adams, 1910; Hamilton, 1940, 1942).

As mechanisms for killing the old but not the young shrews, these causes of death would be of doubtful efficiency, except, of course, the very unspecific "old age." In view of the lack of evidence that the shrew carcasses found are those of old shrews, and whereas there is some doubt that this unexplained mortality is actually greater in the summer and autumn than at other seasons, it does not seem proper to make use of it as a method of disposing of the old animals.

The belief that there is an essential difference between the regulation of the life span of shrews and mice has arisen chiefly because dead shrews (assumed to be old ones) are frequently found in the wild, whereas dead mice seldom are. This led to the supposition that old shrews, unlike old mice, come to an abrupt and mysterious end. A careful study of these naturally occurring shrew carcasses should be carried out before these beliefs are accepted. It is possible that the unpalatability of shrew carcasses is entirely responsible for the fact that they are found more frequently than mouse carcasses. The presence of admittedly unpalatable shrew carcasses in the wild does not seem any more mysterious than the rarity of dead bodies of mice, for in many regions there must be as many dead mice to dispose of as shrews.

Another observation of importance is that captive shrews never die in their nests, nor under the litter in the cage; the bodies are always exposed. If a similar habit were stronger among wild shrews than among wild mice, it would contribute toward the more frequent finding of shrew bodies.

The observations on the short-tailed shrew presented in this paper give little support to the belief that there is an essential difference in the regulation of the life span of shrews, deer mice, and perhaps other small, prolific mammals.



### Summary

1. Shrews have been suspected of being short-lived because old specimens are apparently absent from collections made in the late autumn and winter. The methods of determining age, however, have not been entirely satisfactory. In this study tooth-wear was found to be a reliable indicator of age in wild shrews. The teeth of captive shrews wear more slowly.

2. Wild shrews more than two years old would be practically toothless. The age limitation imposed by tooth-wear, however, is more potential than actual, for only a small fraction of the population survives until the teeth are badly worn.

3. The scarcity of old shrews in autumn and winter can be partly accounted for by "dilution" of the old by numerous progeny. Using an estimated fertility and a constant death rate to balance this fertility, it was estimated that only 7 percent of the shrews at the end of the breeding season would be expected to be old ones that had survived the preceding winter. Actually, 6 percent of 184 shrews trapped from October through March were old. Two specimens apparently had survived two winters.

4. Of 67 shrews that were trapped, marked, and released during the summer, 6 percent were recaptured in the following summer. One, and perhaps more, of these recaptured shrews was more than 400 days old.

5. Of 69 marked deer mice, 4 percent were recaptured in the following summer. This lower rate of survival is not surprising because deer mice are more fertile than shrews.

6. Several males and females captured in the wild have lived to be more than 15 months old in captivity. One wild-caught female lived to more than 30 months of age, and two males born in captivity to 29 and 33 months. They survived three breeding seasons.

7. Because shrew carcasses are frequently found in the wild and mouse carcasses seldom are, many authors have assumed that shrews die of old age or some mysterious cause after they have completed one breeding season. Such an assumption is unwarranted until a careful study of these carcasses has been made. There is not yet proof of any essential difference in the regulation of the life span of short-tailed shrews, deer mice, and perhaps other small, prolific mammals.

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## An Ordovician Ceratiocaris

Rudolf Ruedemann

Among a collection of graptolites sent me by Professor Bradford Willard are remains of crustaceans, one of which is complete enough to be recognized as *Ceratiocaris*. Since this is the first occurrence in the American Ordovician of that genus (heretofore known here only from Silurian and younger rocks), it seems worth while to publish a note about it.

Professor Willard has sent me the following brief statement about the age of the fossils:

In 1936 Bradford Willard and the late Professor Freeman Ward collected graptolites from a dump at the Hess slate quarry number 22, at Lynnport, Lehigh County, Pennsylvania (1). The material was submitted to Dr. Rudolf Ruedemann for identification. Dr. Ruedemann noted certain arthropods among the graptolites and kindly consented to study the specimens. The specimens were taken from Martinsburg Slate of the Ordovician. More precisely, the age of the fossils is probably middle Eden. Pulaski fossils occur in higher sandstones, and Eden fossils have been collected from underlying shaly or sandy beds (2). The specimens were found in a black, silty slate in which slaty cleavage was less well developed than in much of the country rock. This lack of cleavage accounts for their preservation, for the fossils would have been destroyed or made inaccessible had the bedding been obliterated.

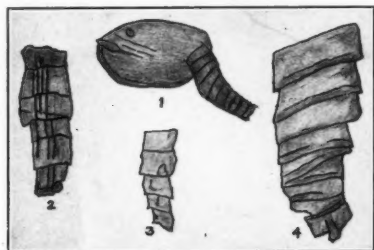


Fig. 1. Holotype of *Ceratiocaris willardi* Ruedemann, sp. nov.  $\times 5$ .

Figs. 2, 3. Portions of the abdomina of unknown crustaceans, probably also belonging to *Ceratiocaris*.  $\times 5$ .

Fig. 4. Holotype of *Ceratiocaris* (?) *wardi* Willard.

### Description of the Fossils

#### Genus CERATIOCARIS M'Coy

##### *Ceratiocaris willardi* Ruedemann, sp. nov.

*Description.* Carapace smooth, small and subovate, with fairly convex dorsal margin, slightly projecting frontal, nearly straight ventral and obliquely truncated posterior margins. Eye-node is suggested above and behind the antero-

dorsal angle, where a lanceolate rostrum is located. Body not complete. Ten segments are present, with the posterior portion of the body segments incomplete. Eight of these extend beyond the body, but some of them may have been pushed outward. Telson not preserved. Length of holotype 5mm; width 2mm.

*Horizon and locality.* Ordovician Martinsburg shale at Lynnport, Pa.

CERATIOCARIS sp.

*Ceratiocaris* (?) *wardi* Willard, sp. nov.

With the type of *Ceratiocaris willardi* were found much larger fragments of the abdomina and more elongate segments, indicating the presence of other larger species probably also belonging to *Ceratiocaris*. The largest specimen, at Professor Willard's request, is designated *Ceratiocaris* (?) *wardi* sp. nov., with Professor Willard as author.

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